SOIL IS
SOIL DOES
SOIL CAN DO

Soil Science Society of North Carolina
2015

Stan Buol

Is This Soil?

Looks more like a basket to mixed fruit

Aha, It's Soils not Soil

23,000 Plus Kinds of Soil in the United States and Many More in the World

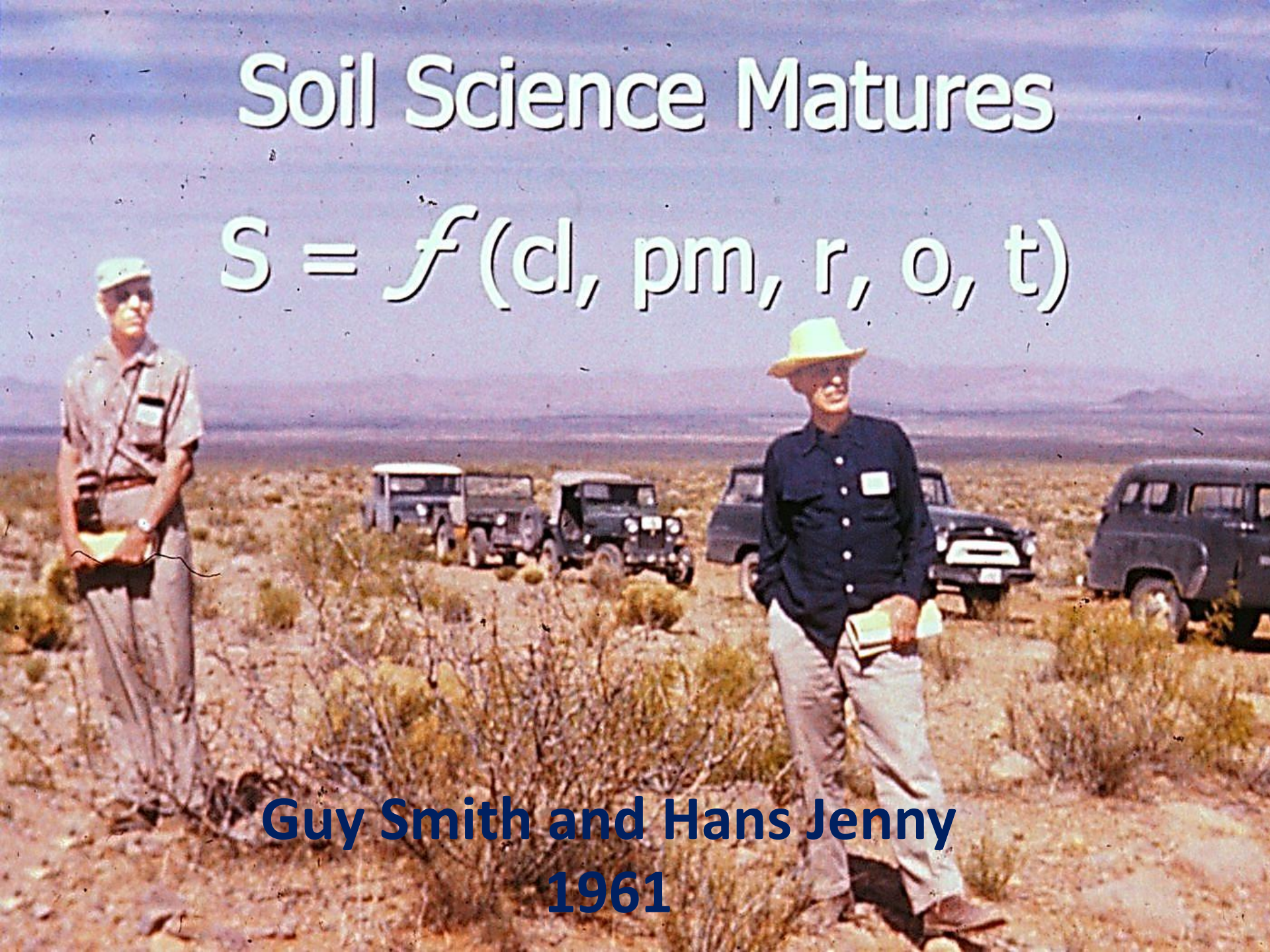
Soil Must Provide

1. Support to hold plants upright.
2. Temperature compatible with plants to be grown.
3. Moisture compatible with plants to be grown.
4. Chemicals in amounts and rates necessary for the plants grown.

Approximate Elemental Content of Corn, Soybeans, and Plantation Pine

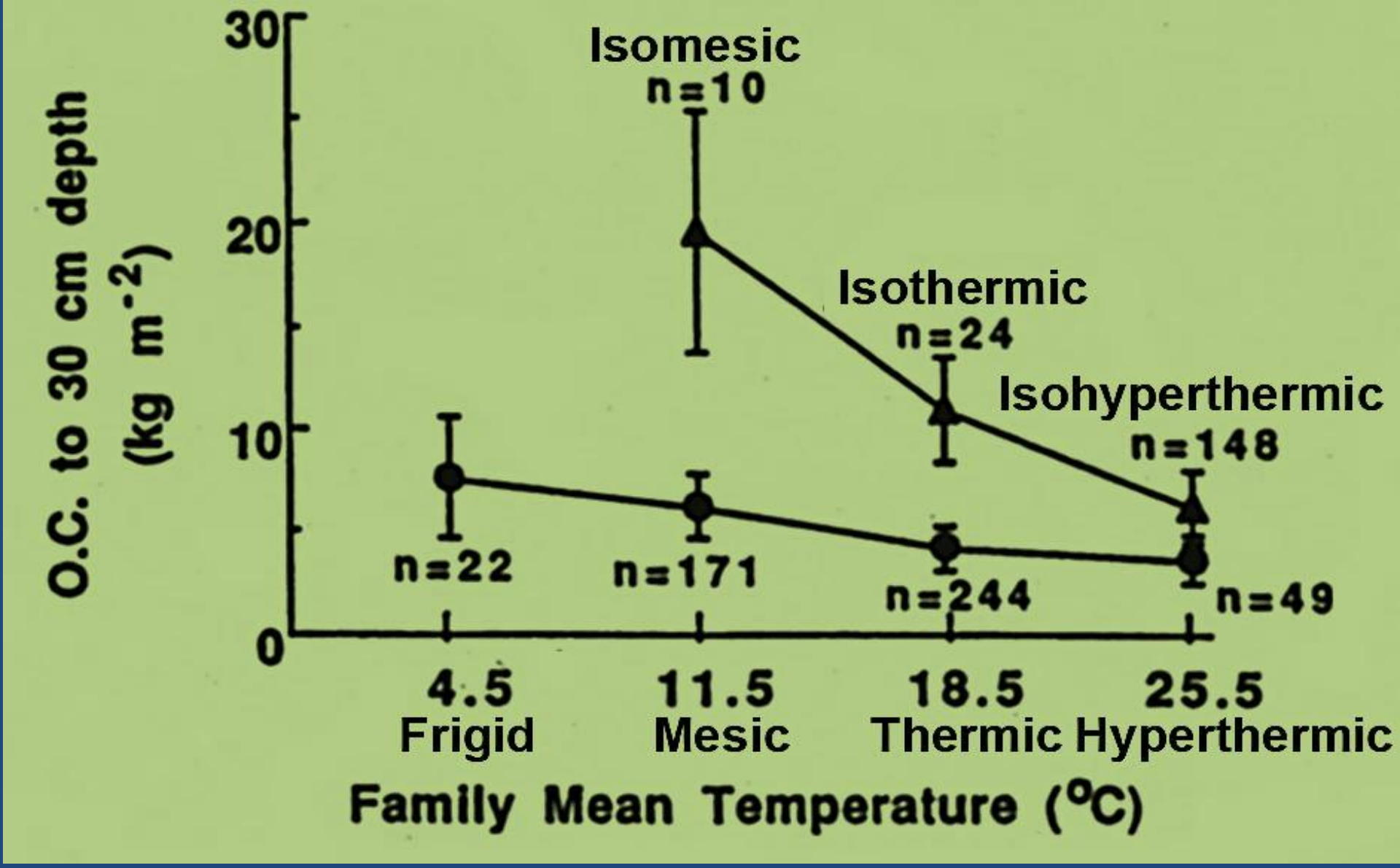
Food crops require N, P, and K amounts in 50 to 90 days approximating the amounts required by 22 year old trees.

Crop	Yield	N	P	K	Ca
	Per Acre	Lbs. per Acre			
Corn (Grain)	150 Bu	135	23	33	16
Corn (Stover)	4.5 T	100	16	120	28
Soybean (Grain)	40 Bu	150	16	46	7
Soybean (Straw)	1.5 T	18	2	20	
22-Yr. Pine (Stem)	28.9 T	51	4	32	46
22-Yr. Pine (Total)	37.8 T	161	17	80	159


Soil Science Matures
S = f (cl, pm, r, o, t)
Guy Smith and Hans Jenny
1961

At the time Dr. Jenny wrote his famous 1941 book, Factors of Soil Formation confirming concepts of soil genesis most of his data, and that of Dokuchaev before him came from the glaciated areas of Europe and the Midwest in the United States. In the last paragraph of his book Jenny wrote that his famous formula worked well in the Midwest but when attempting to apply it in California correlations of factors of soil formation to soil properties were notoriously poor and studies often led to disappointment.

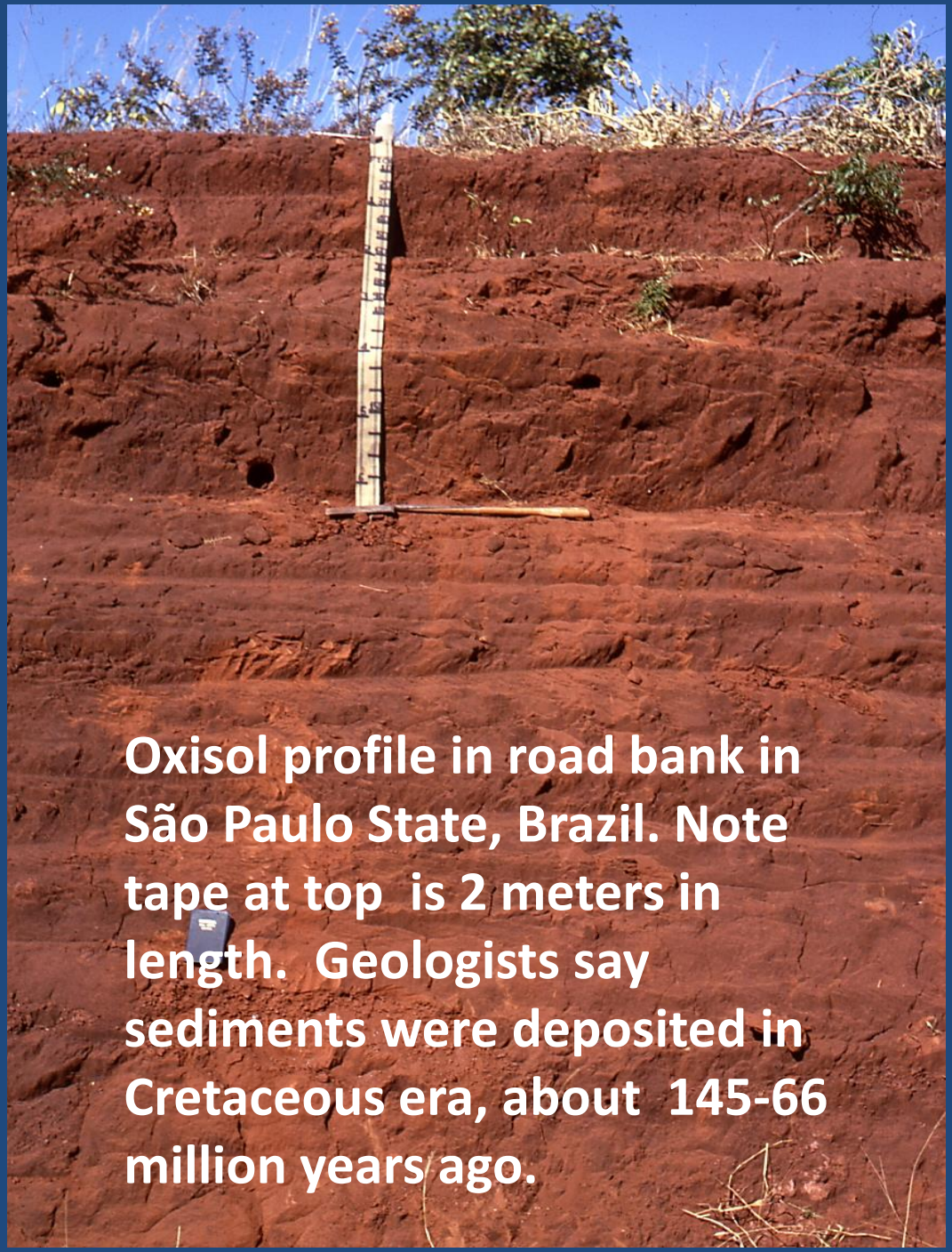
The advent of Soil Taxonomy, led by Guy Smith in 1960 established quantitative soil temperature, moisture, and chemical criteria related to the use and management when classifying soils. This replaced concepts of soil genesis related to factors of soil formation as classification criteria such as Young Soils, Old Soils, Prairie Soils, Tropical Soils, Etc. permitting close relationships of what a soil is classified as to what a soil does and what a soil can do.



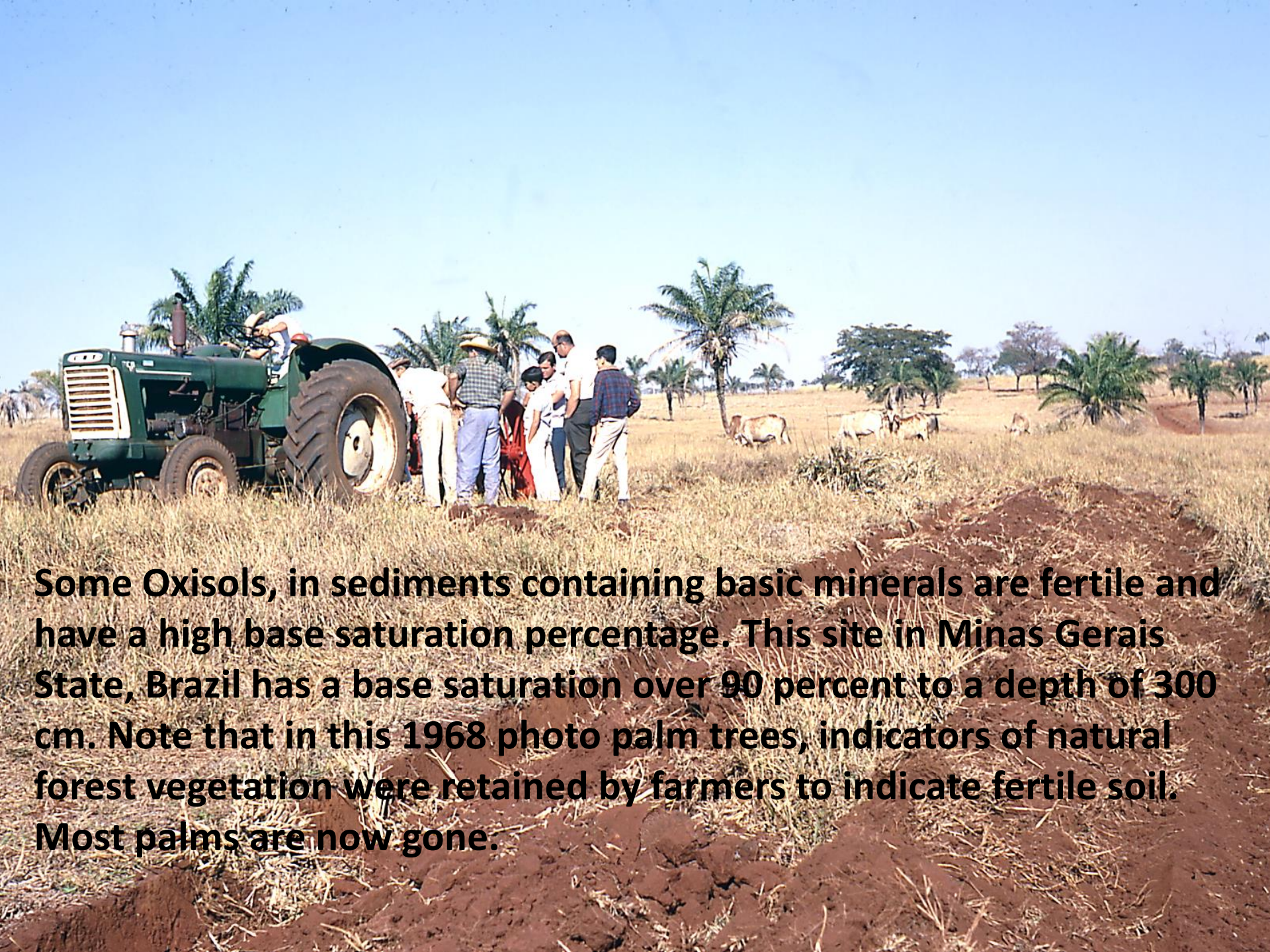
Steady state organic carbon content by family soil temperature regimes. Note that soils in tropical (Iso-) latitudes have more OC than temperate soils with same mean annual soil temperature.

The Cerrado area in Brazil covers approximately 400 million acres, predominately infertile Oxisols, and declared unsuitable for agriculture in 1965.

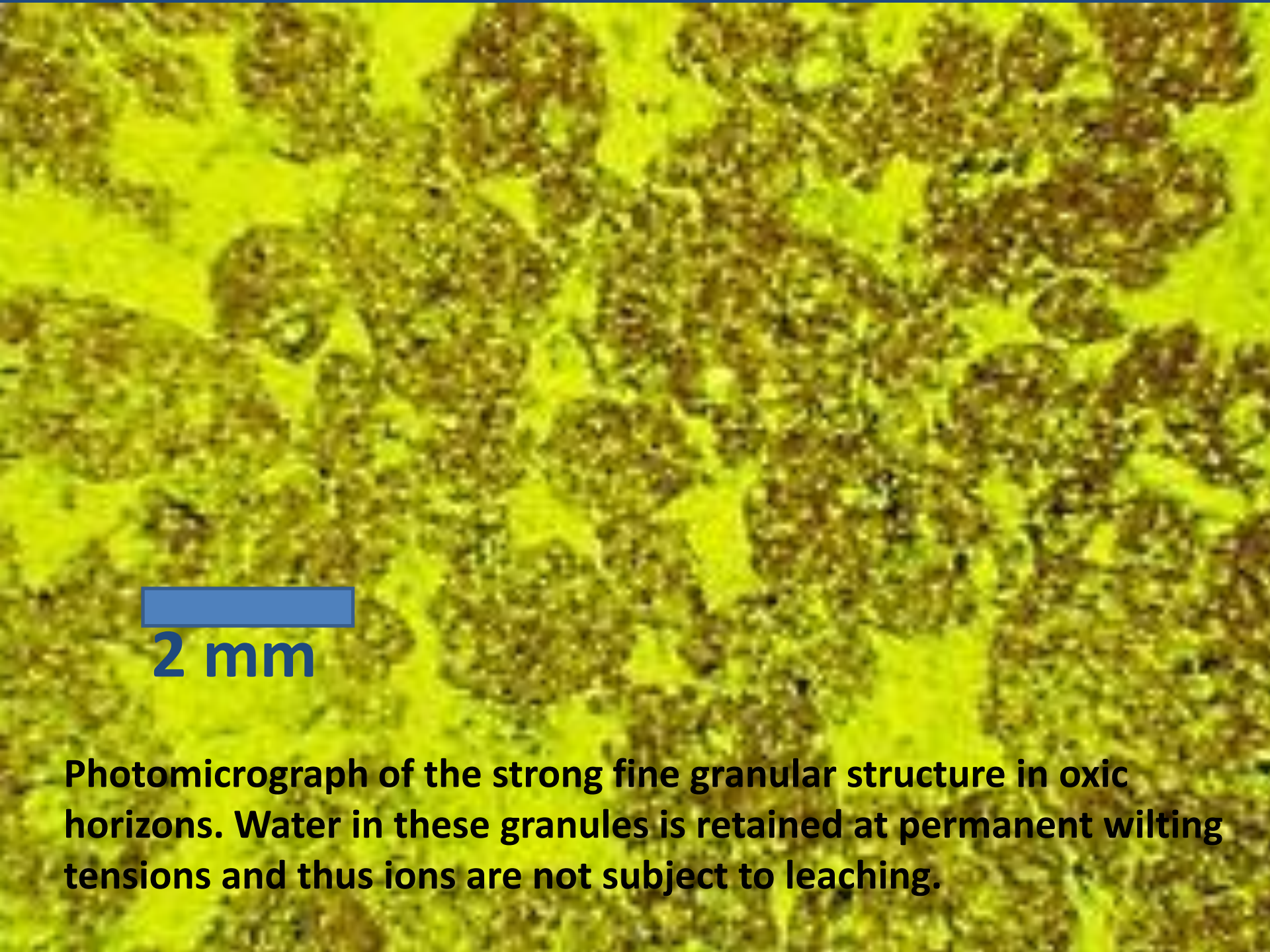
Cerrado Harvest.Com


Oxisol profile in road bank in São Paulo State, Brazil. Note tape at top is 2 meters in length. Geologists say sediments were deposited in Cretaceous era, about 145-66 million years ago.


Oxisol in Queensland, Australia. Oxisols occupy about 23 % of tropical land area and are present in all soil moisture regimes.

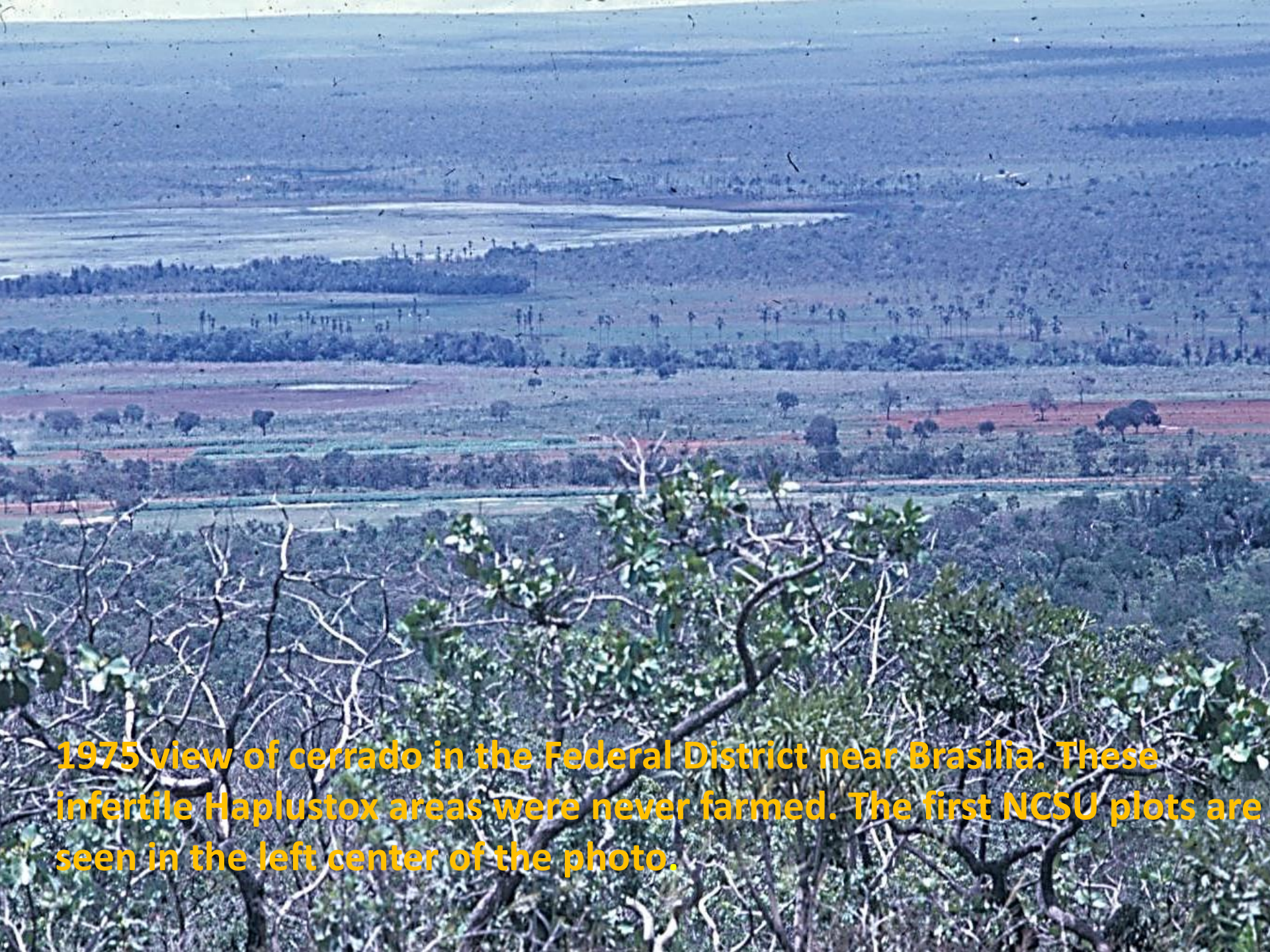


Some Oxisols, in sediments containing basic minerals are fertile and have a high base saturation percentage. This site in Minas Gerais State, Brazil has a base saturation over 90 percent to a depth of 300 cm. Note that in this 1968 photo palm trees, indicators of natural forest vegetation were retained by farmers to indicate fertile soil. Most palms are now gone.

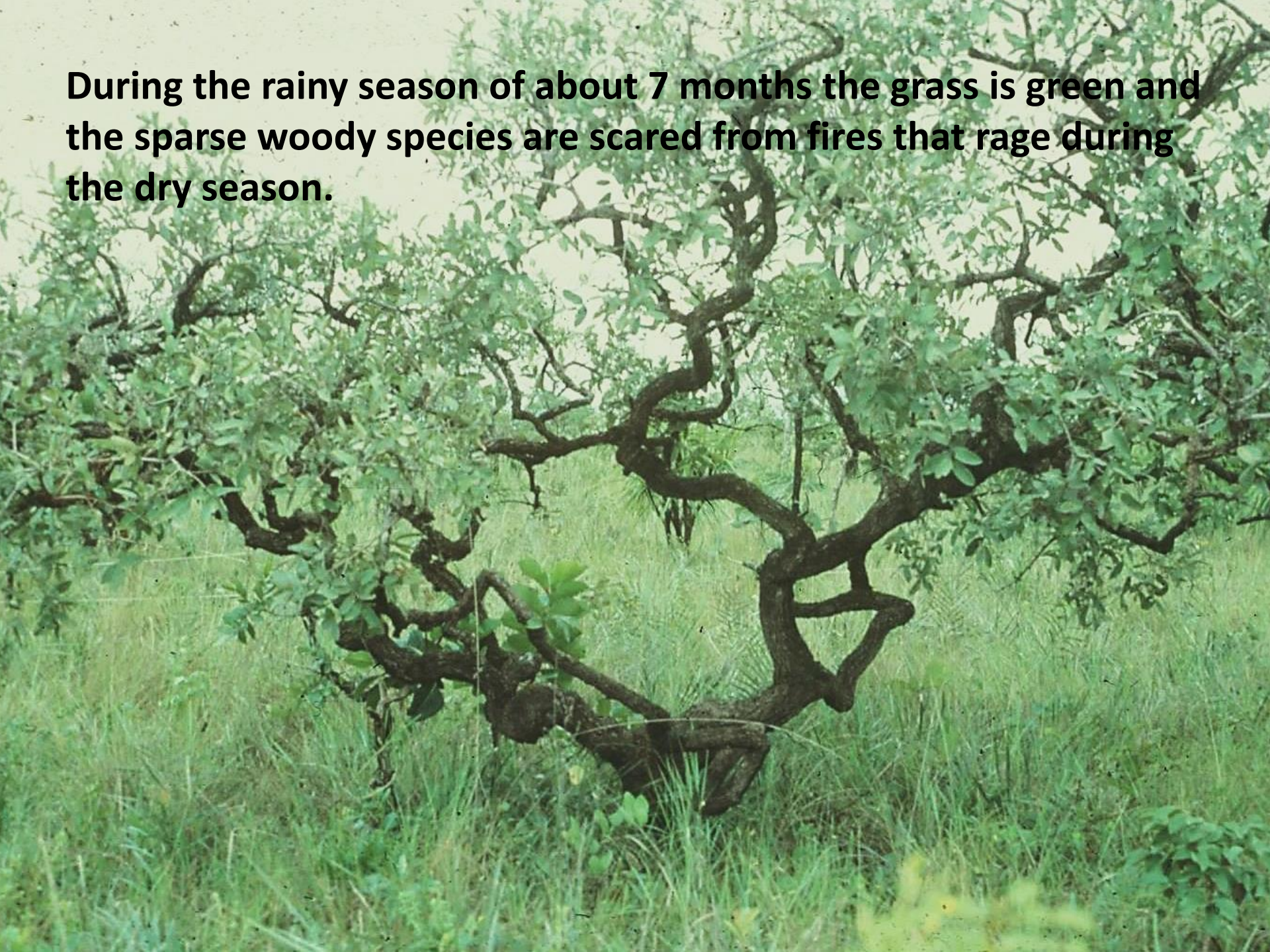


Photomicrograph of the strong fine granular structure in oxic horizons. Water in these granules is retained at permanent wilting tensions and thus ions are not subject to leaching.

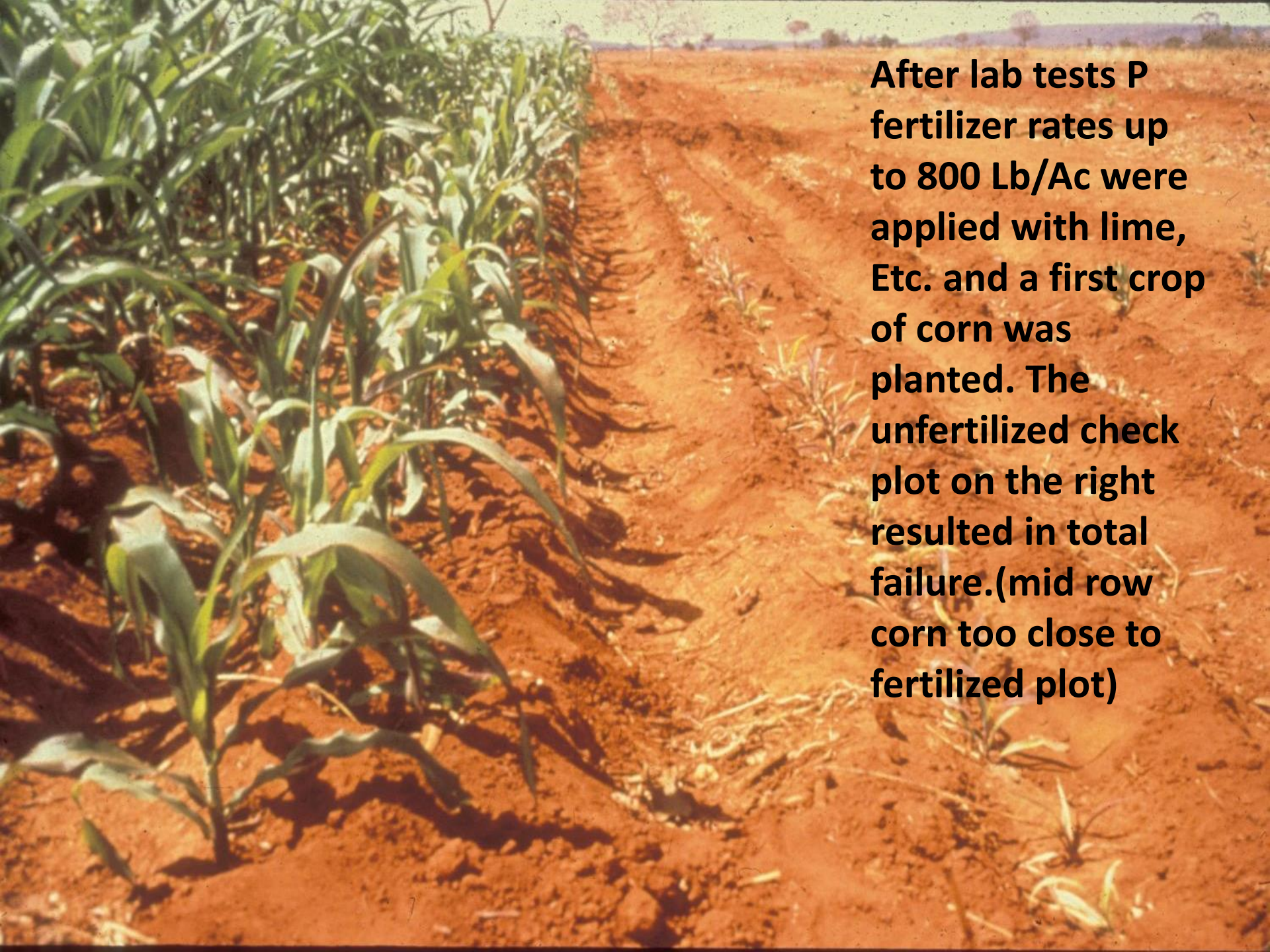
Gene Kamprath and Fred Cox in the Federal District, Brazil as NCSU explores research possibilities in the cerrado in 1973



1975 view of cerrado in the Federal District near Brasilia. These infertile Haplustox areas were never farmed. The first NCSU plots are seen in the left center of the photo.

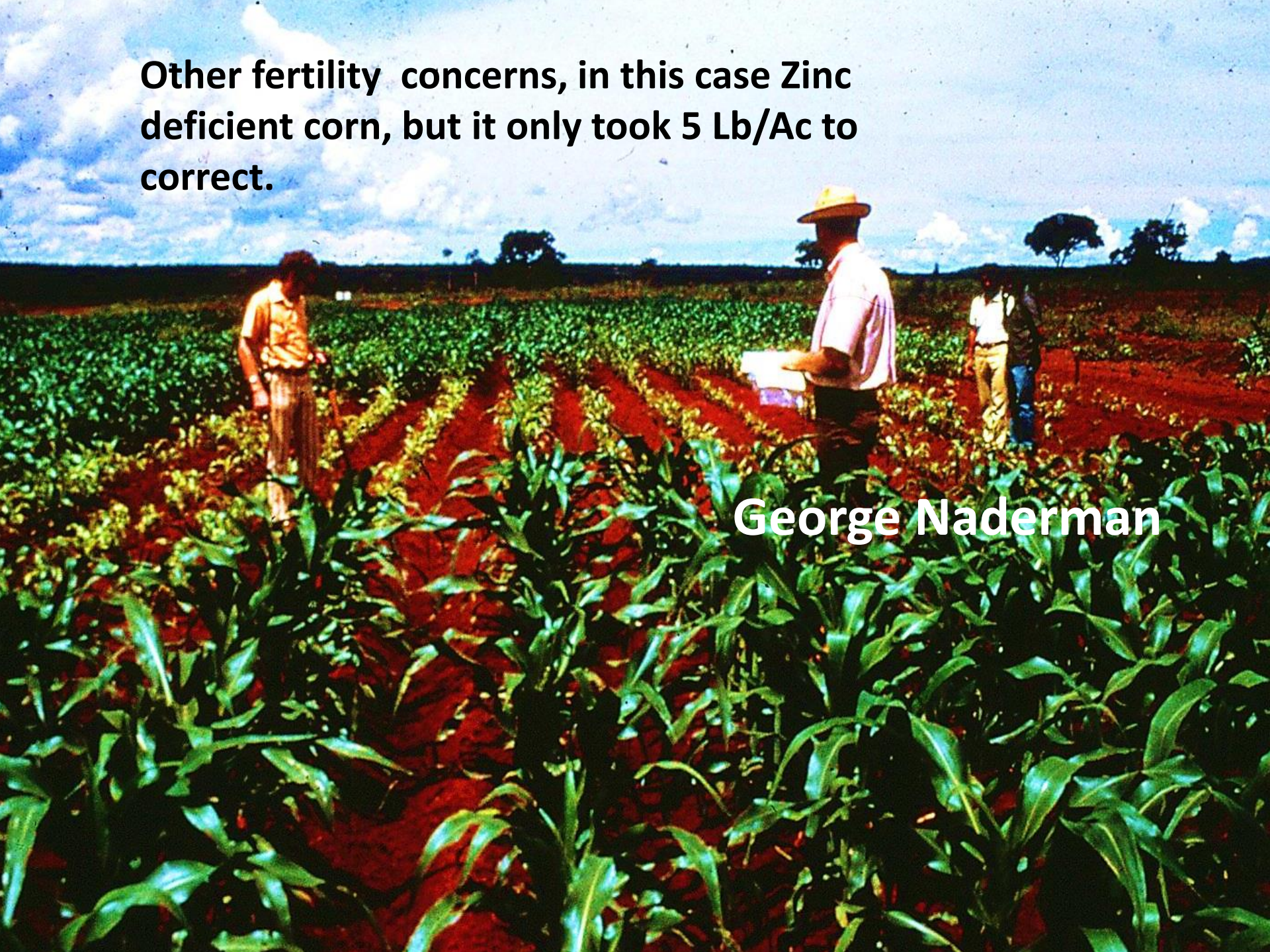

During the rainy season of about 7 months the grass is green and the sparse woody species are scared from fires that rage during the dry season.

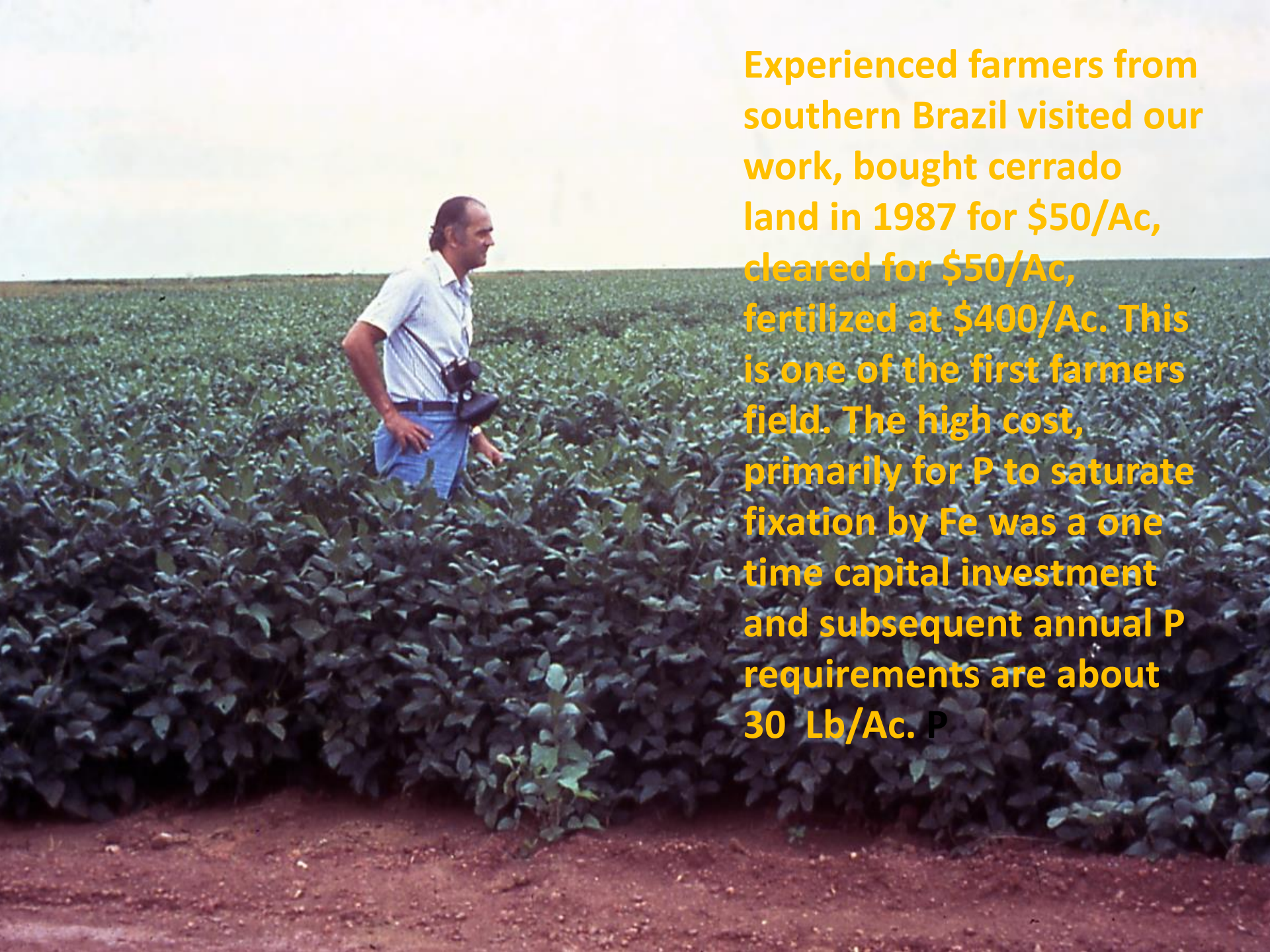

During the dry season the grasses remain because there are essentially no native mammals and attempts to graze cattle resulted in the cattle dying because Ca and P contents in the vegetation was insufficient to maintain bone structure. Brazilians referred to the cerrado as a place to loose cattle, not graze cattle.


After lab tests P fertilizer rates up to 800 Lb/Ac were applied with lime, Etc. and a first crop of corn was planted. The unfertilized check plot on the right resulted in total failure.(mid row corn too close to fertilized plot)

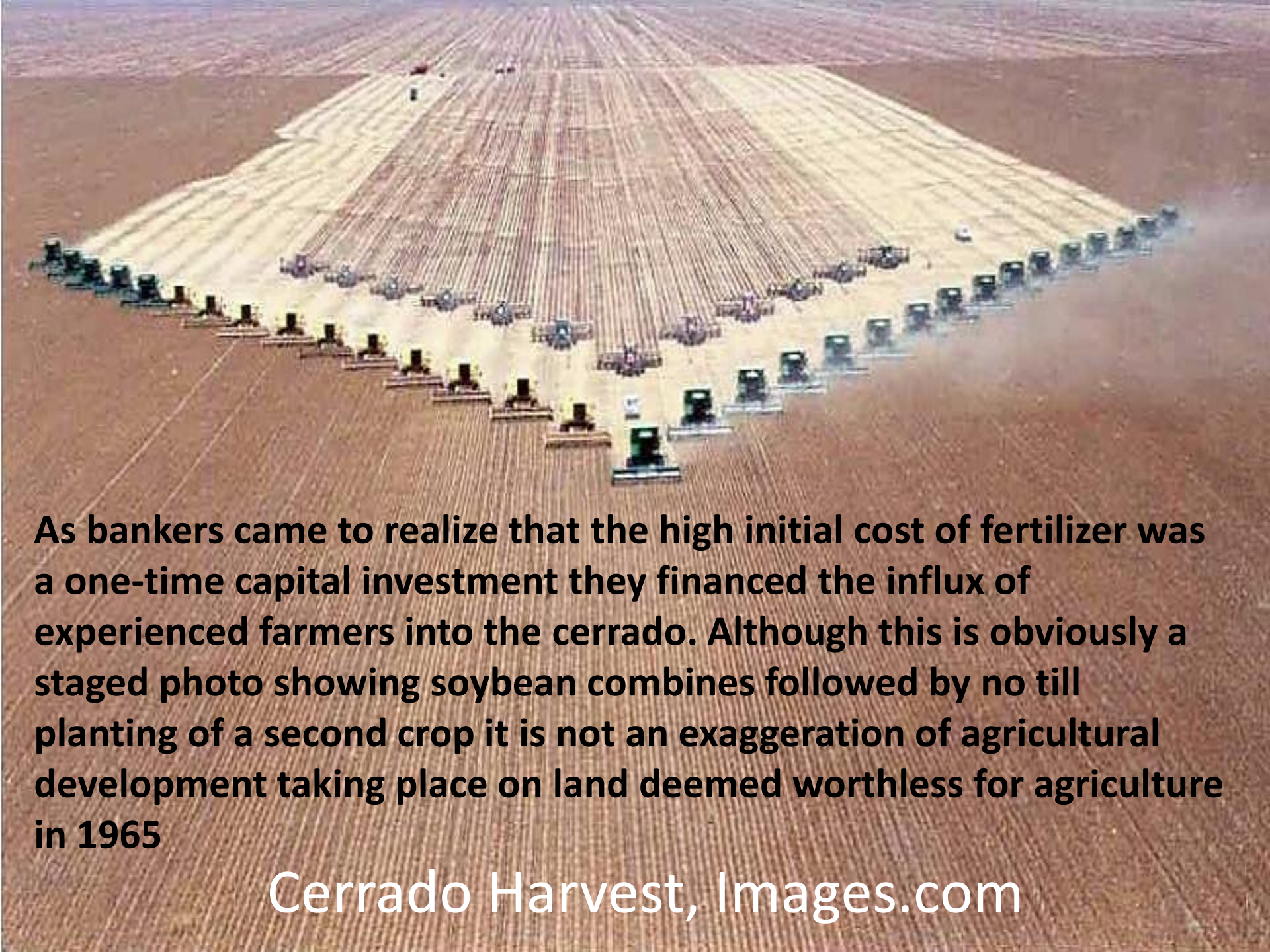

Plot 14 planted with no fertilizer.
Plot 13, adequate P, lime, Etc.
14
13


Properly fertilized soybean plot
with two unfertilized rows as a
check plot in the foreground.


Other fertility concerns, in this case Zinc deficient corn, but it only took 5 Lb/Ac to correct.
George Naderman



Experienced farmers from southern Brazil visited our work, bought cerrado land in 1987 for $50/Ac, cleared for $50/Ac, fertilized at $400/Ac. This is one of the first farmers field. The high cost, primarily for P to saturate fixation by Fe was a one time capital investment and subsequent annual P requirements are about 30 Lb/Ac. P

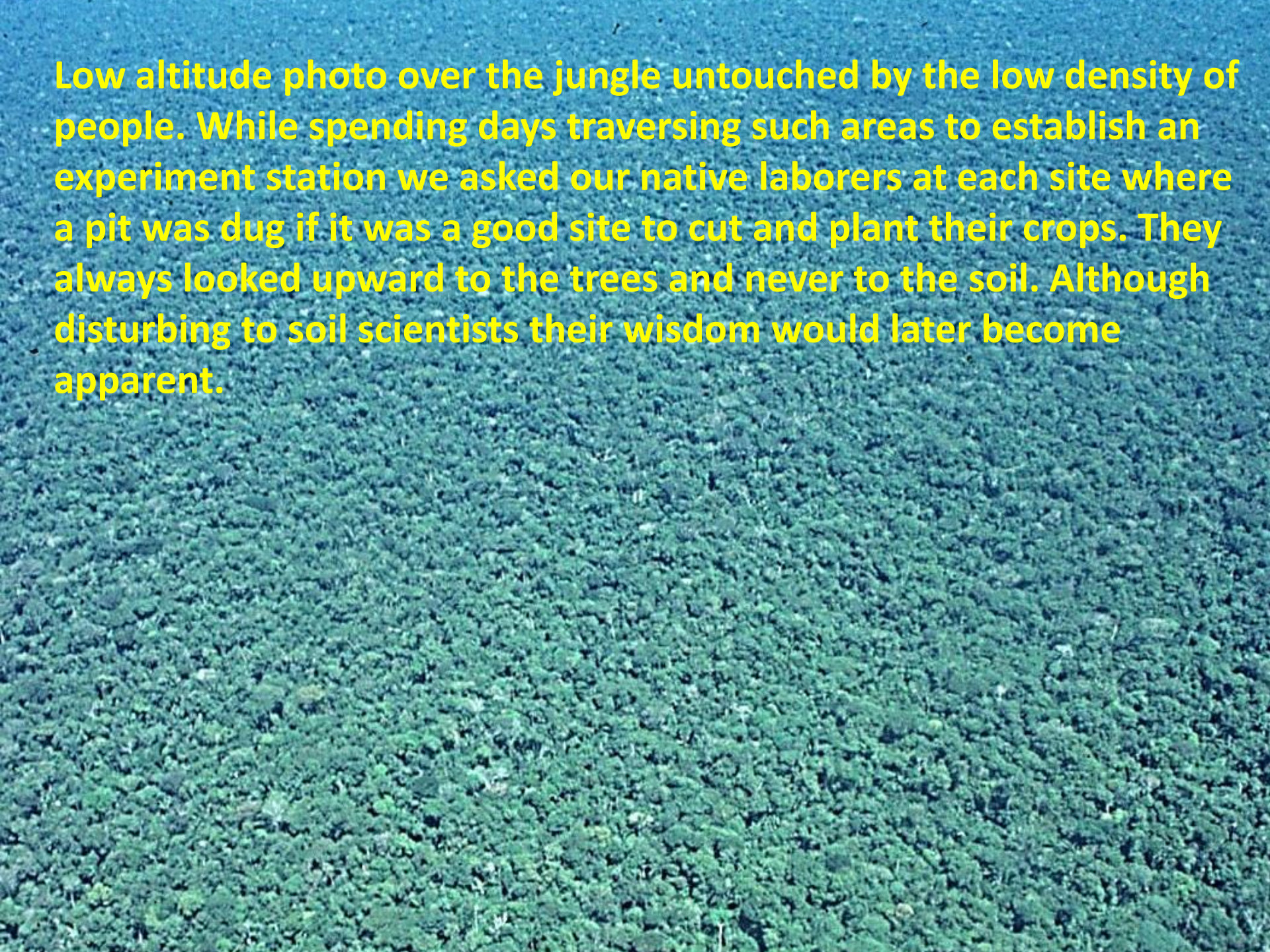


As bankers came to realize that the high initial cost of fertilizer was a one-time capital investment they financed the influx of experienced farmers into the cerrado. Although this is obviously a staged photo showing soybean combines followed by no till planting of a second crop it is not an exaggeration of agricultural development taking place on land deemed worthless for agriculture in 1965

Cerrado Harvest, Images.com

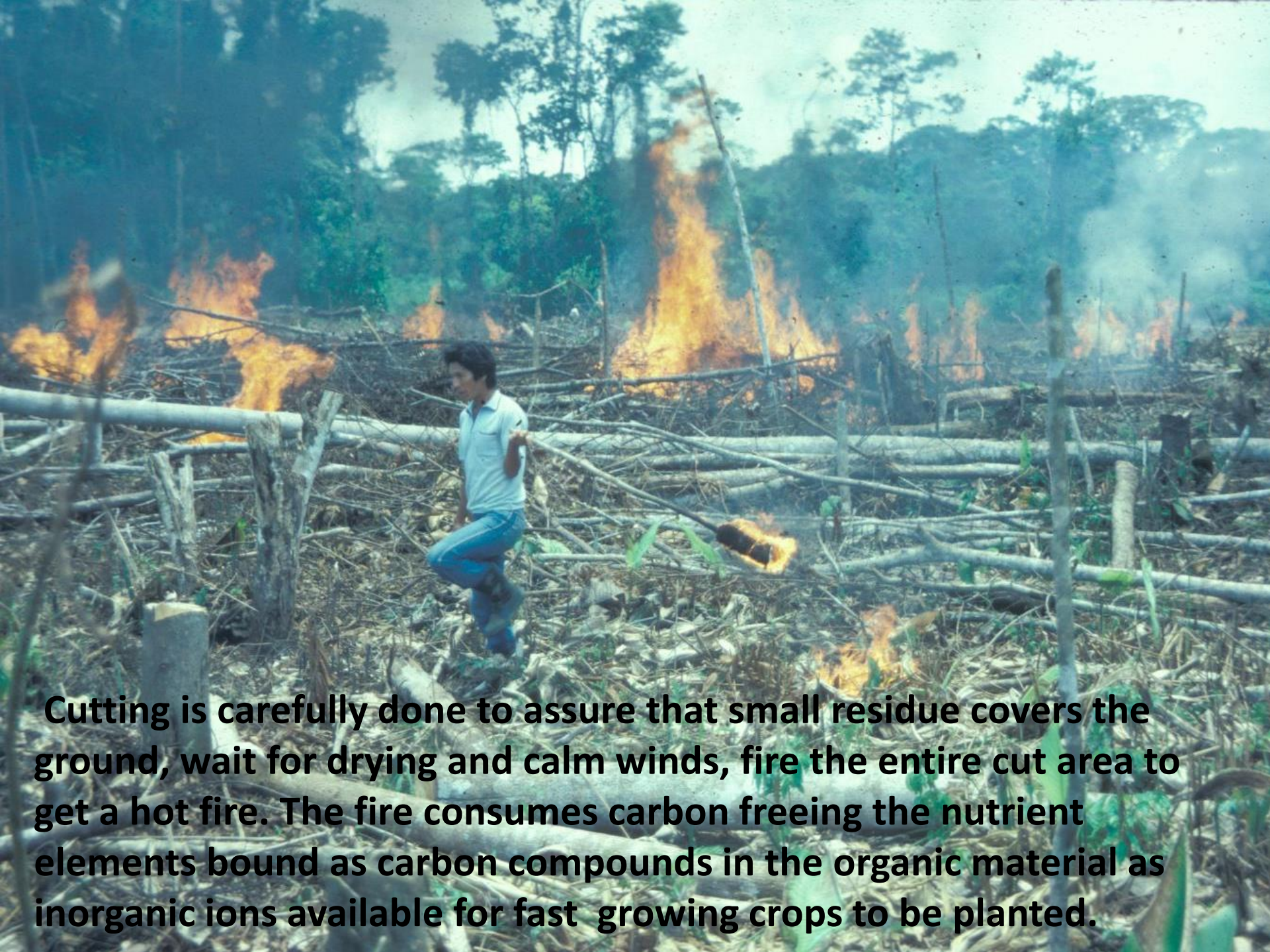
NCSU work in the Amazon jungle at Yurimaguas, Peru.


While selecting a site for an experiment station a group of kids came by and a professor never misses a chance to lecture.
Pedro Sanchez 1971



Low altitude photo over the jungle untouched by the low density of people. While spending days traversing such areas to establish an experiment station we asked our native laborers at each site where a pit was dug if it was a good site to cut and plant their crops. They always looked upward to the trees and never to the soil. Although disturbing to soil scientists their wisdom would later become apparent.

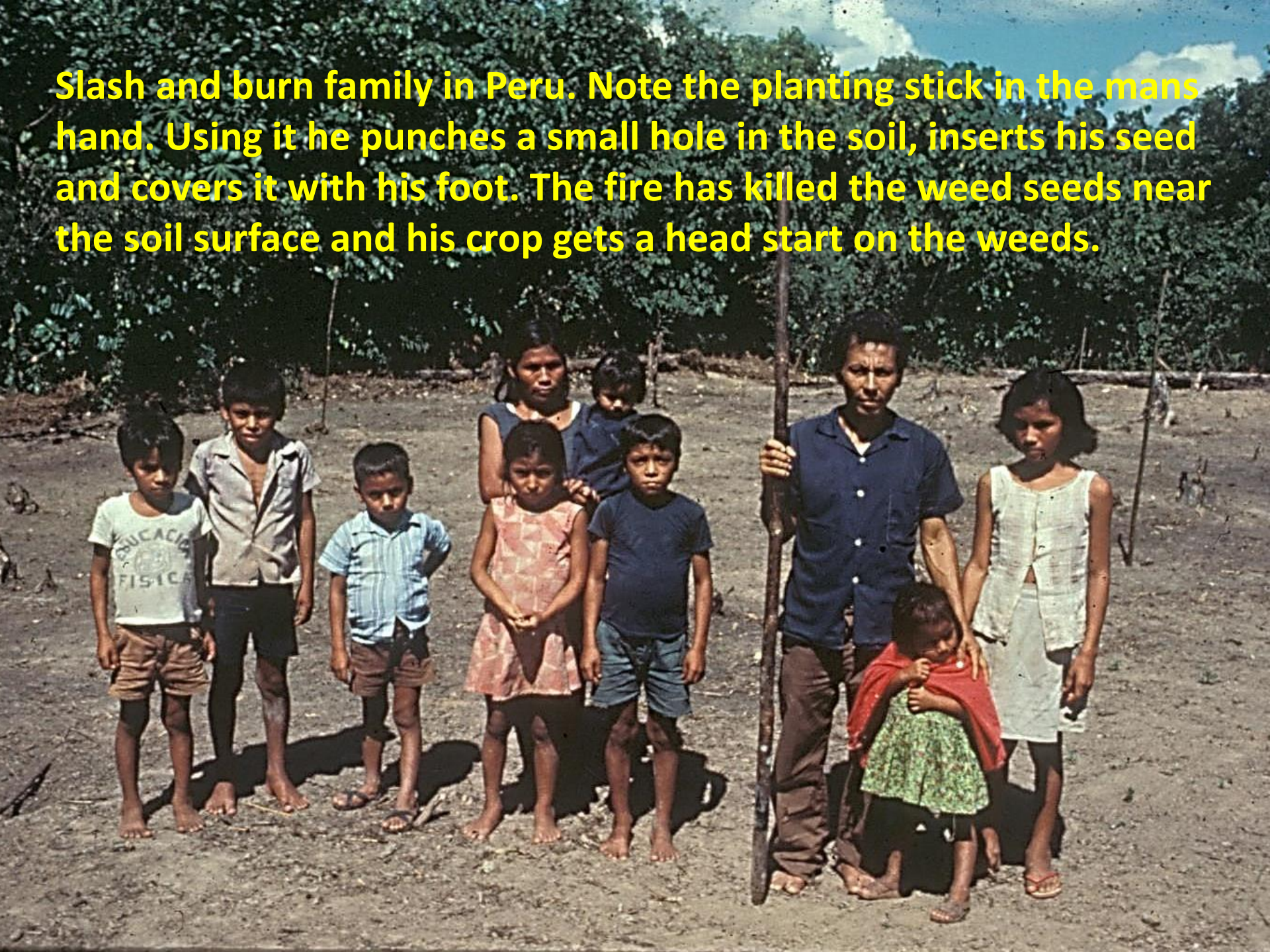
Occasionally evidence of slash and burn subsistence farming could be seen. Indigenous farmers cut an area, plant a crop or two and as fertility becomes too low for crops they cut and burn another area and allow slow growing native vegetation to grow in abandon field.

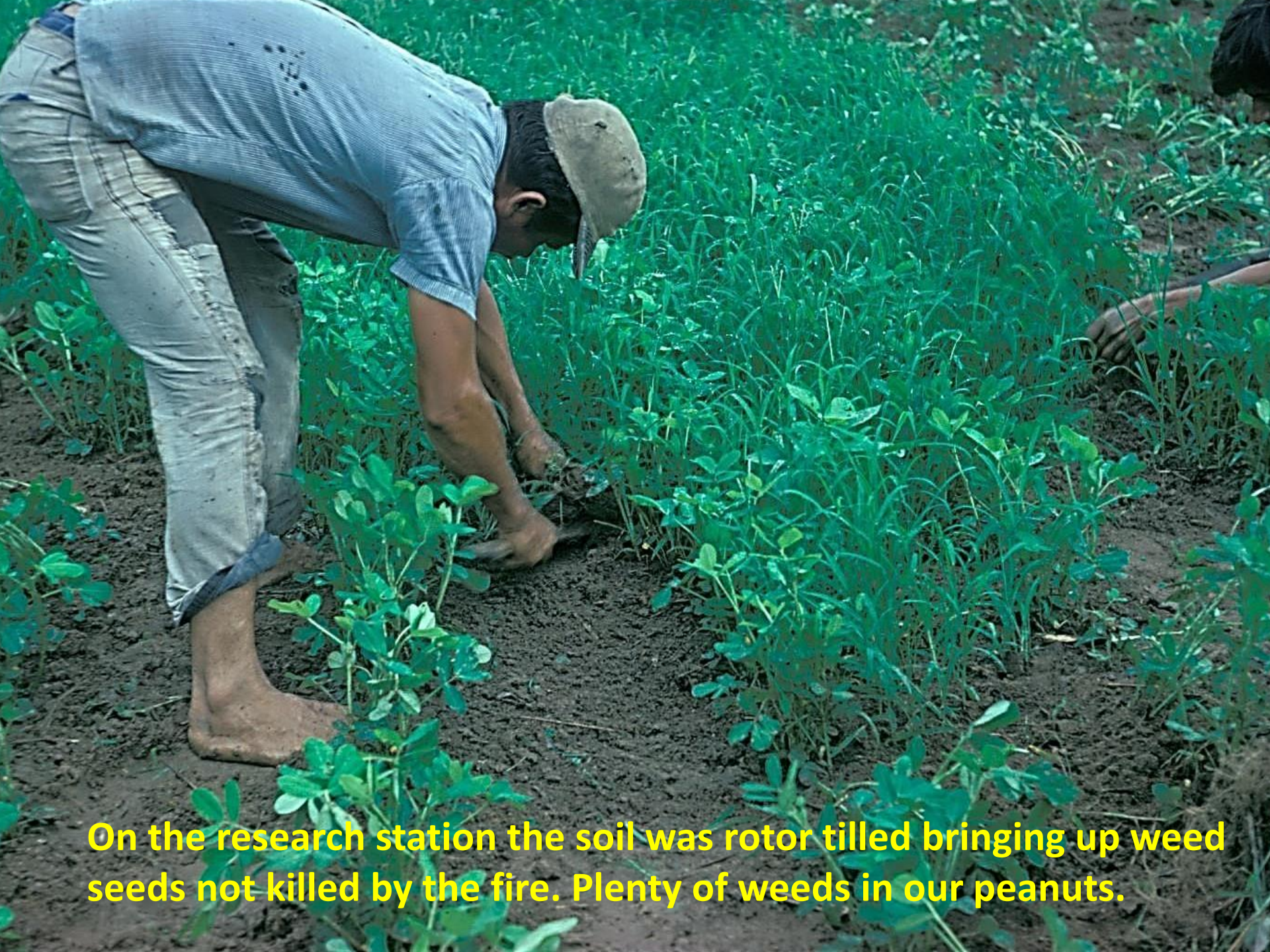


Cutting is carefully done to assure that small residue covers the ground, wait for drying and calm winds, fire the entire cut area to get a hot fire. The fire consumes carbon freeing the nutrient elements bound as carbon compounds in the organic material as inorganic ions available for fast growing crops to be planted.


Farmers field planted to cassava. Note complete cover of ashes.
Chris Seubert, Jerry Tyler, Frank Doggett, 1974

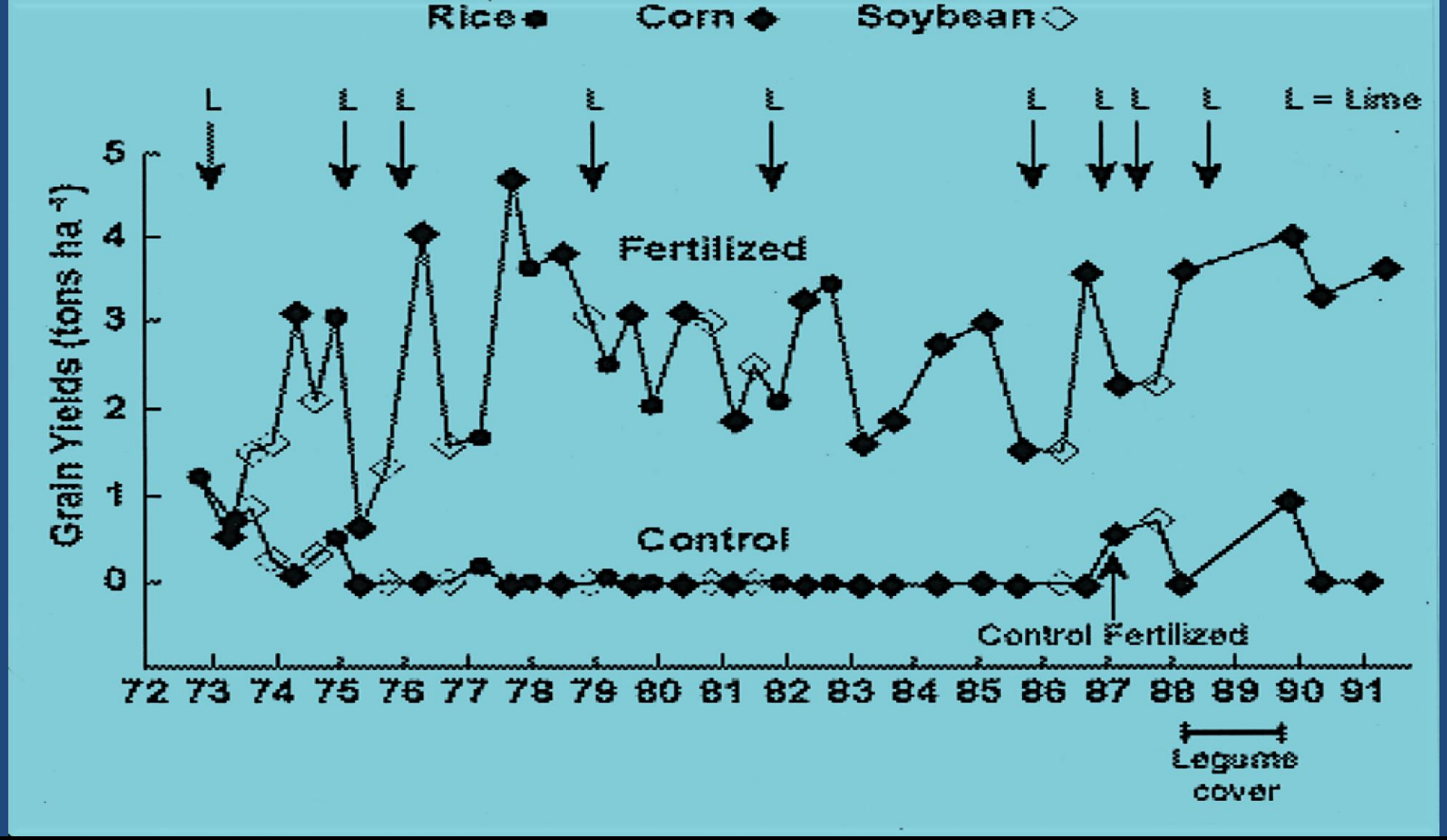
Inexperienced slash and burn farmer's field in Sumatra, Indonesia wherein there was not a complete cover of burnable material. Where there was a good burn, evidenced by black ashes the rice will grow well. Where no fire the rice is poor. I now knew why our laborers in Peru looked up to select a good site to plant. They wanted abundant burnable material to cover the ground and provide a quantity of ash.


Slash and burn family in Peru. Note the planting stick in the mans hand. Using it he punches a small hole in the soil, inserts his seed and covers it with his foot. The fire has killed the weed seeds near the soil surface and his crop gets a head start on the weeds.



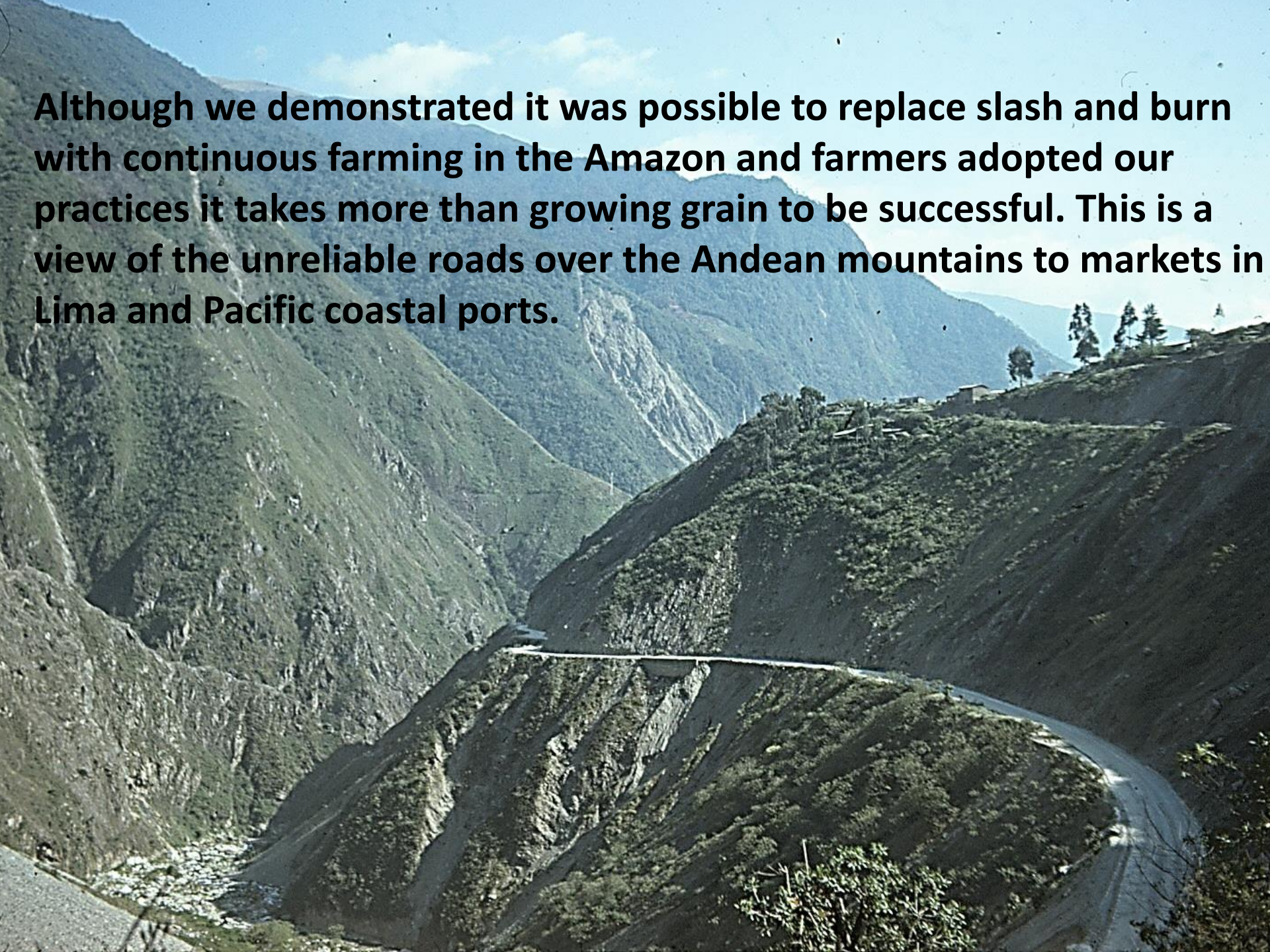
On the research station the soil was rotor tilled bringing up weed seeds not killed by the fire. Plenty of weeds in our peanuts.


Typic Paleudult, fine-loamy, siliceous, subactive, isohyperthermic
This was the predominate soil for experiments at Yurimagaus.



Control and fertilized plot yields 1972-91: Control plot yields were zero after first 2 years until mistakenly fertilized in 19 87 and after legume fallow in 1988-89. Low fertilized plot yields in 1975 were caused by Mg deficiency after applying only obtainable calcite lime.


Bob McCollum 1991 corn



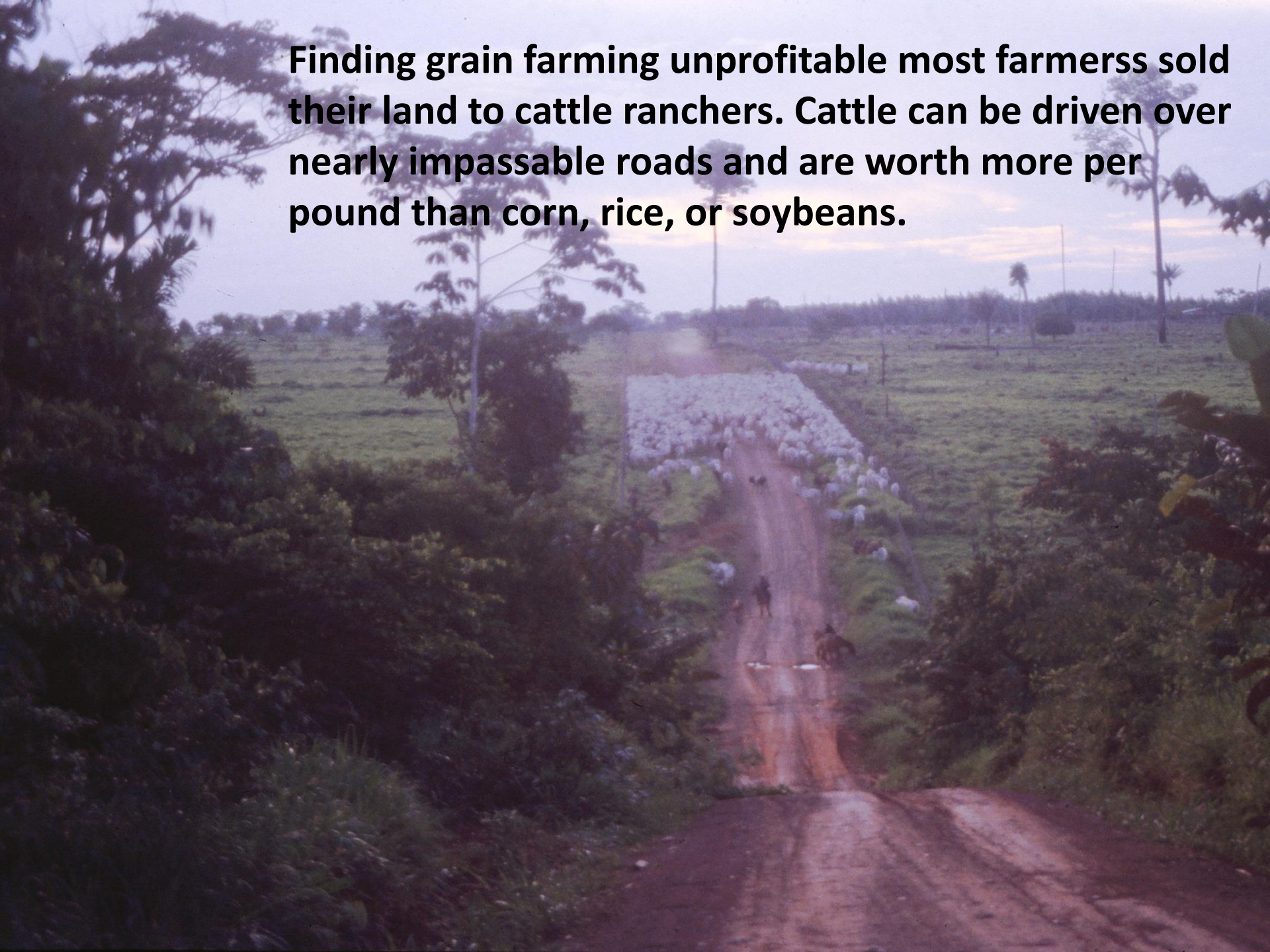
Although we demonstrated it was possible to replace slash and burn with continuous farming in the Amazon and farmers adopted our practices it takes more than growing grain to be successful. This is a view of the unreliable roads over the Andean mountains to markets in Lima and Pacific coastal ports.


Roads in the jungle are often impassable.

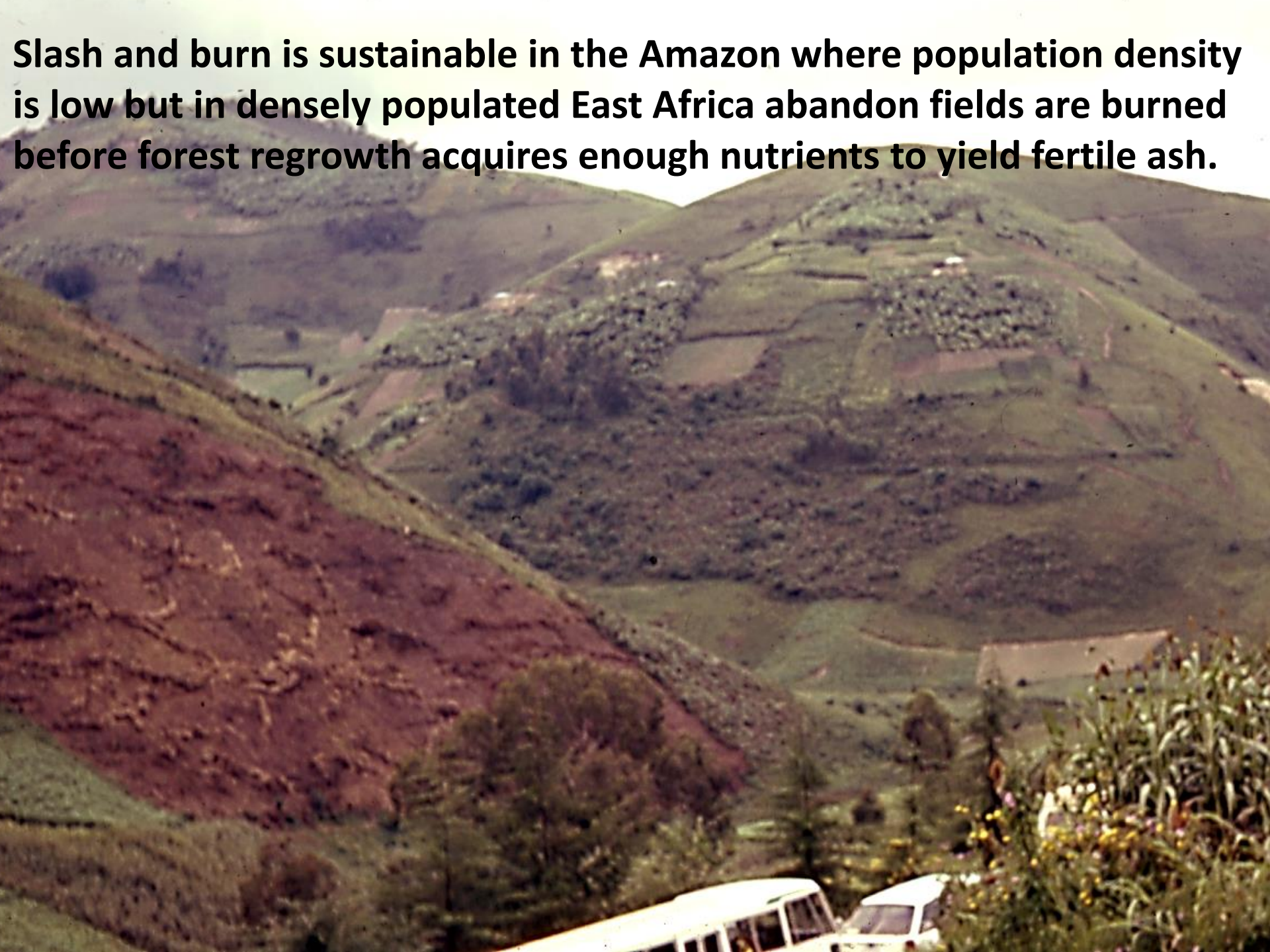

Dale Bandy and Walter Couto examining logs cut by loggers who built existing roads only for their needs.

Bridges built by loggers were not maintained and often impassable.

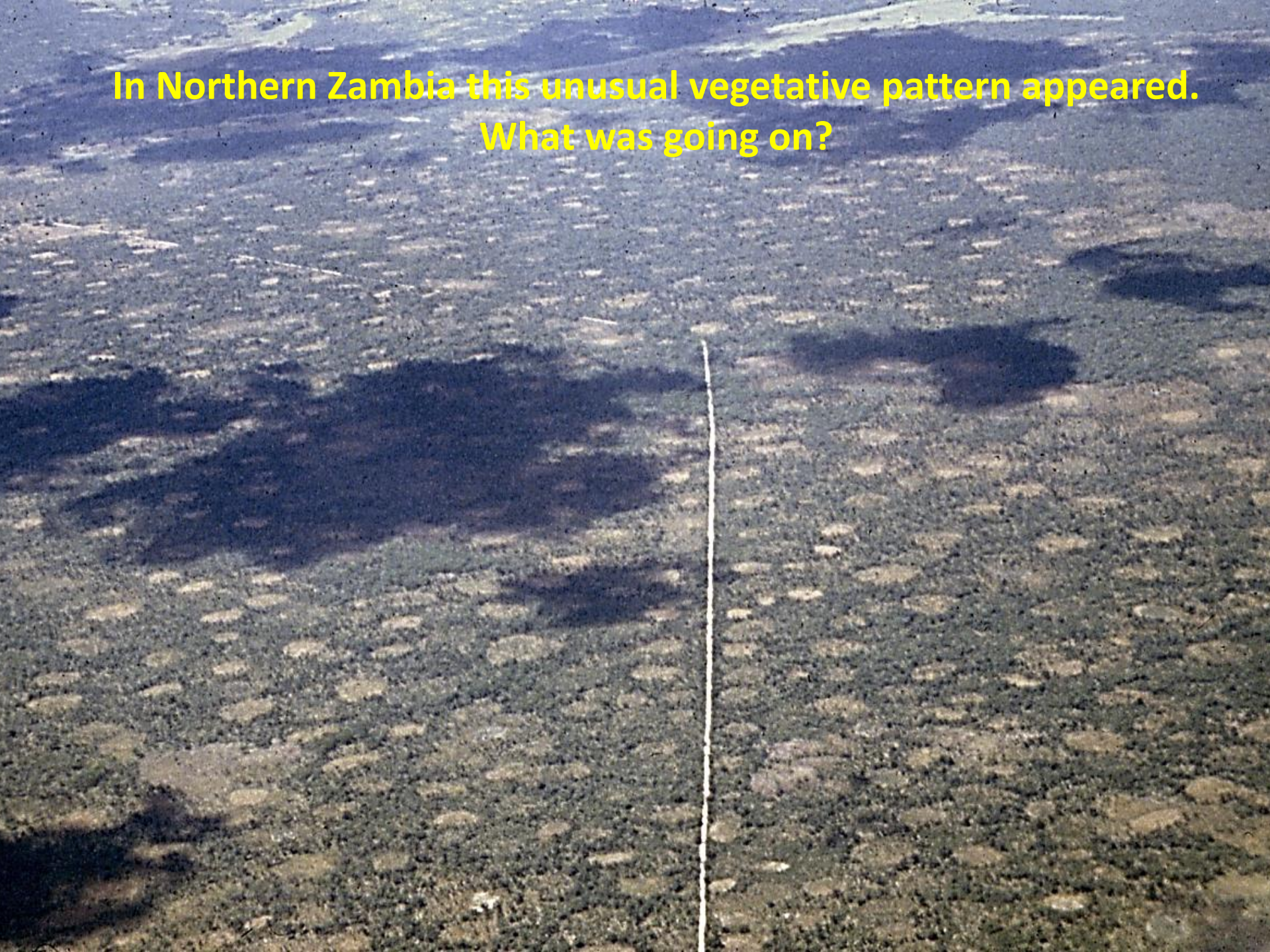
The grain farmers grew had to be bagged and loaded on barges for transport several hundred miles to urban center markets.

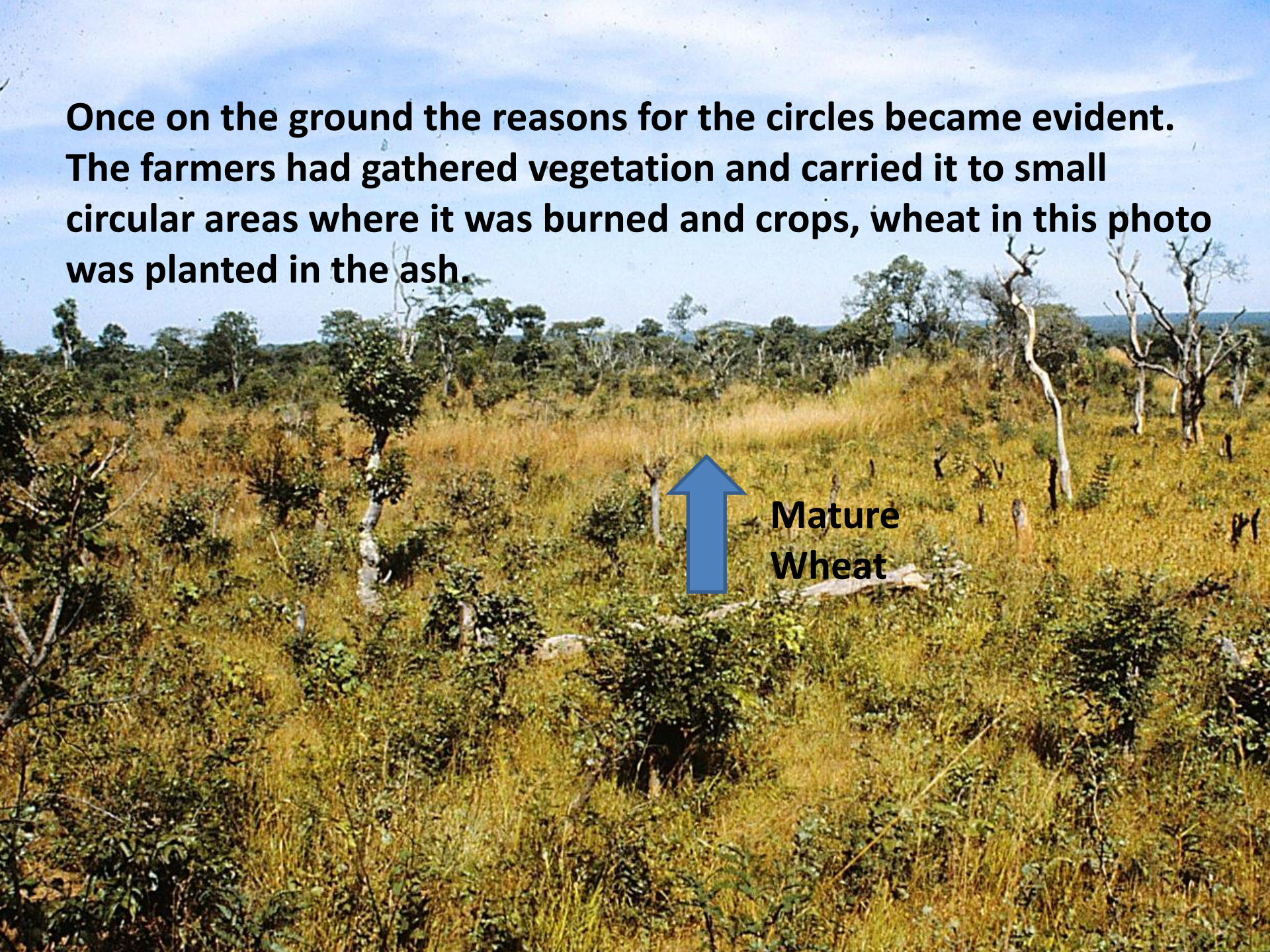


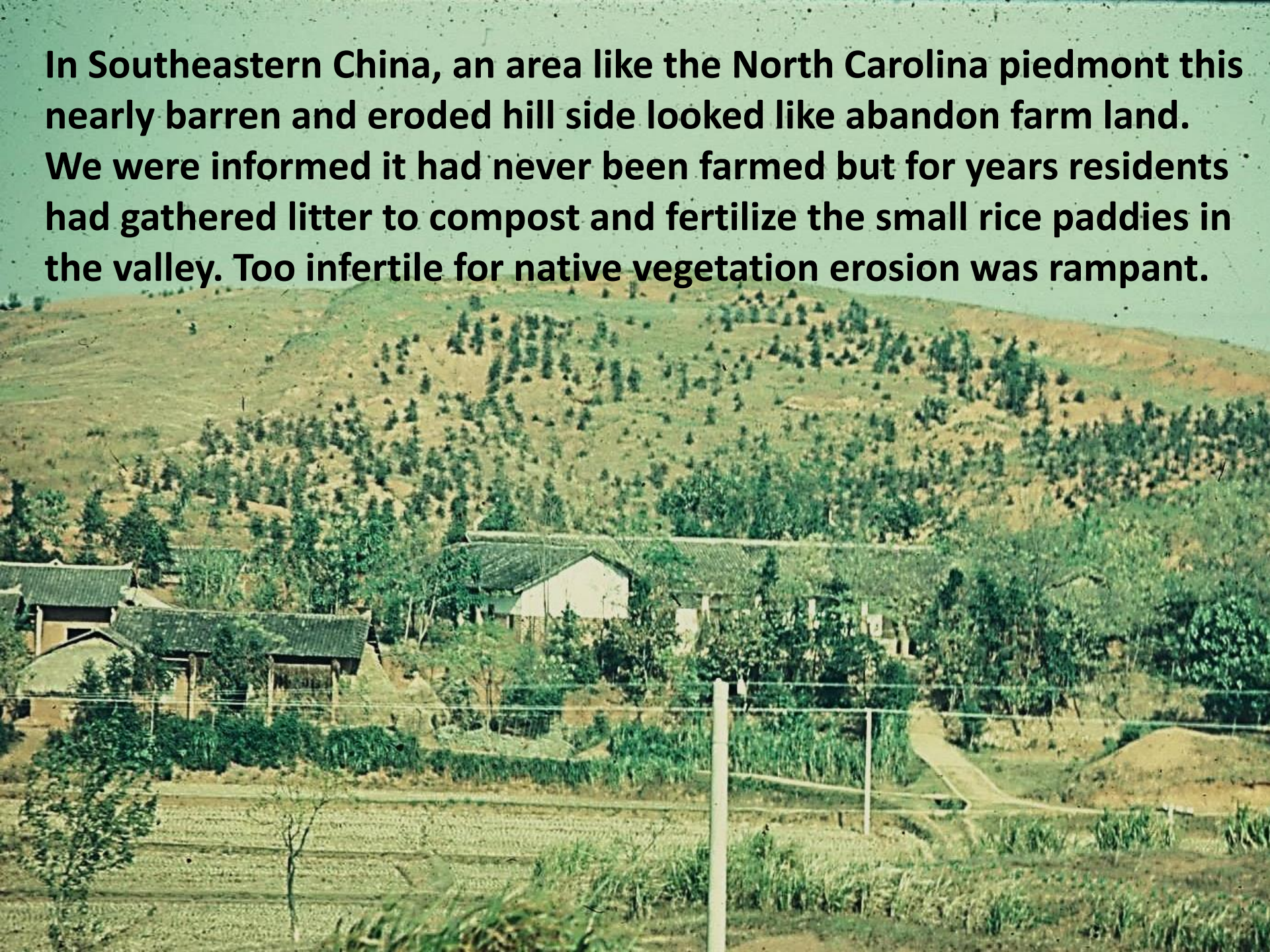
Finding grain farming unprofitable most farmerss sold their land to cattle ranchers. Cattle can be driven over nearly impassable roads and are worth more per pound than corn, rice, or soybeans.


Slash and burn is sustainable in the Amazon where population density is low but in densely populated East Africa abandon fields are burned before forest regrowth acquires enough nutrients to yield fertile ash.


With insufficient ash corn crops look like this.


In Northern Zambia this unusual vegetative pattern appeared.
What was going on?


Once on the ground the reasons for the circles became evident. The farmers had gathered vegetation and carried it to small circular areas where it was burned and crops, wheat in this photo was planted in the ash.
Mature Wheat



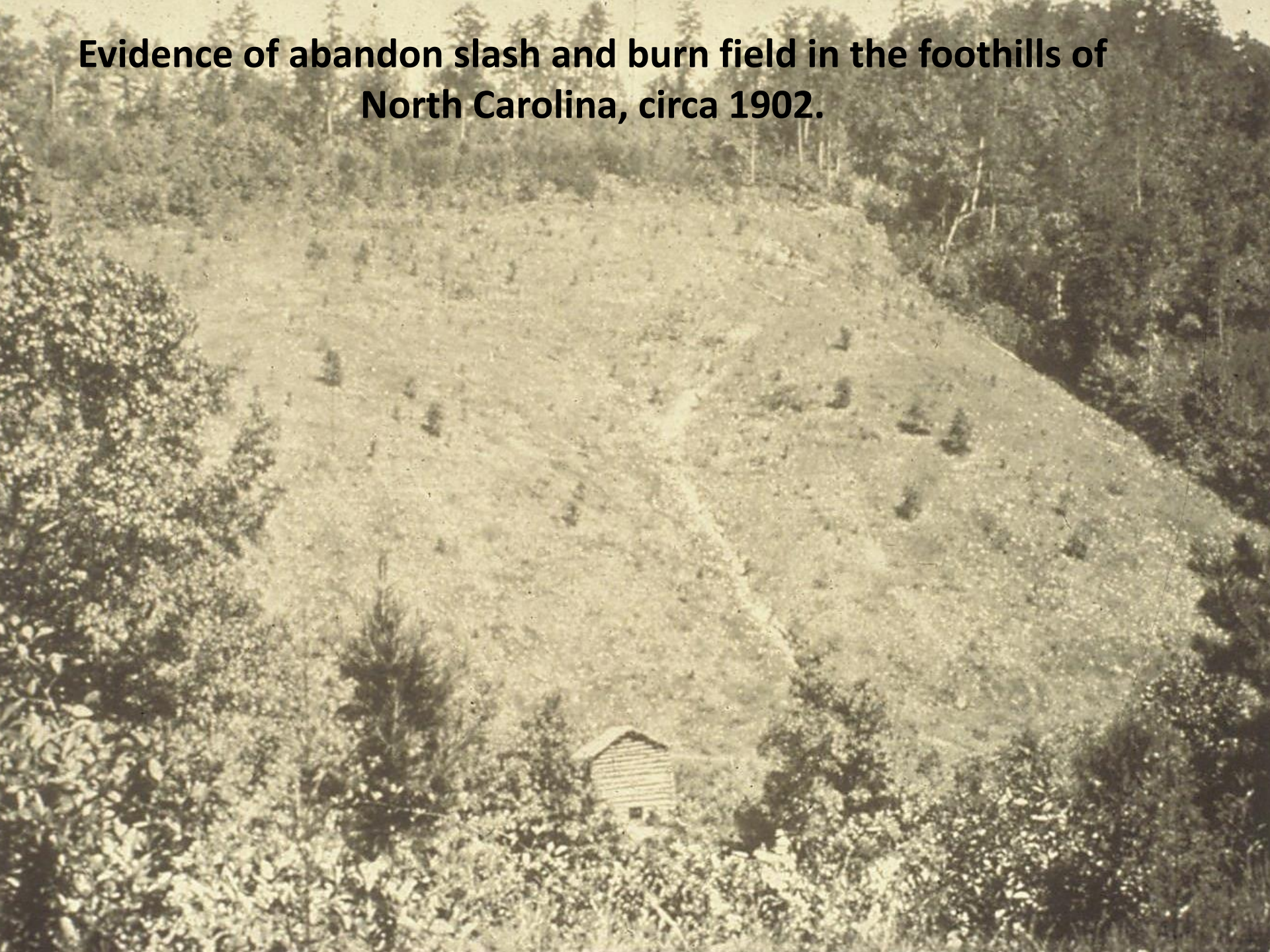
In Southeastern China, an area like the North Carolina piedmont this nearly barren and eroded hill side looked like abandon farm land. We were informed it had never been farmed but for years residents had gathered litter to compost and fertilize the small rice paddies in the valley. Too infertile for native vegetation erosion was rampant.

Slash and Burn in North Carolina

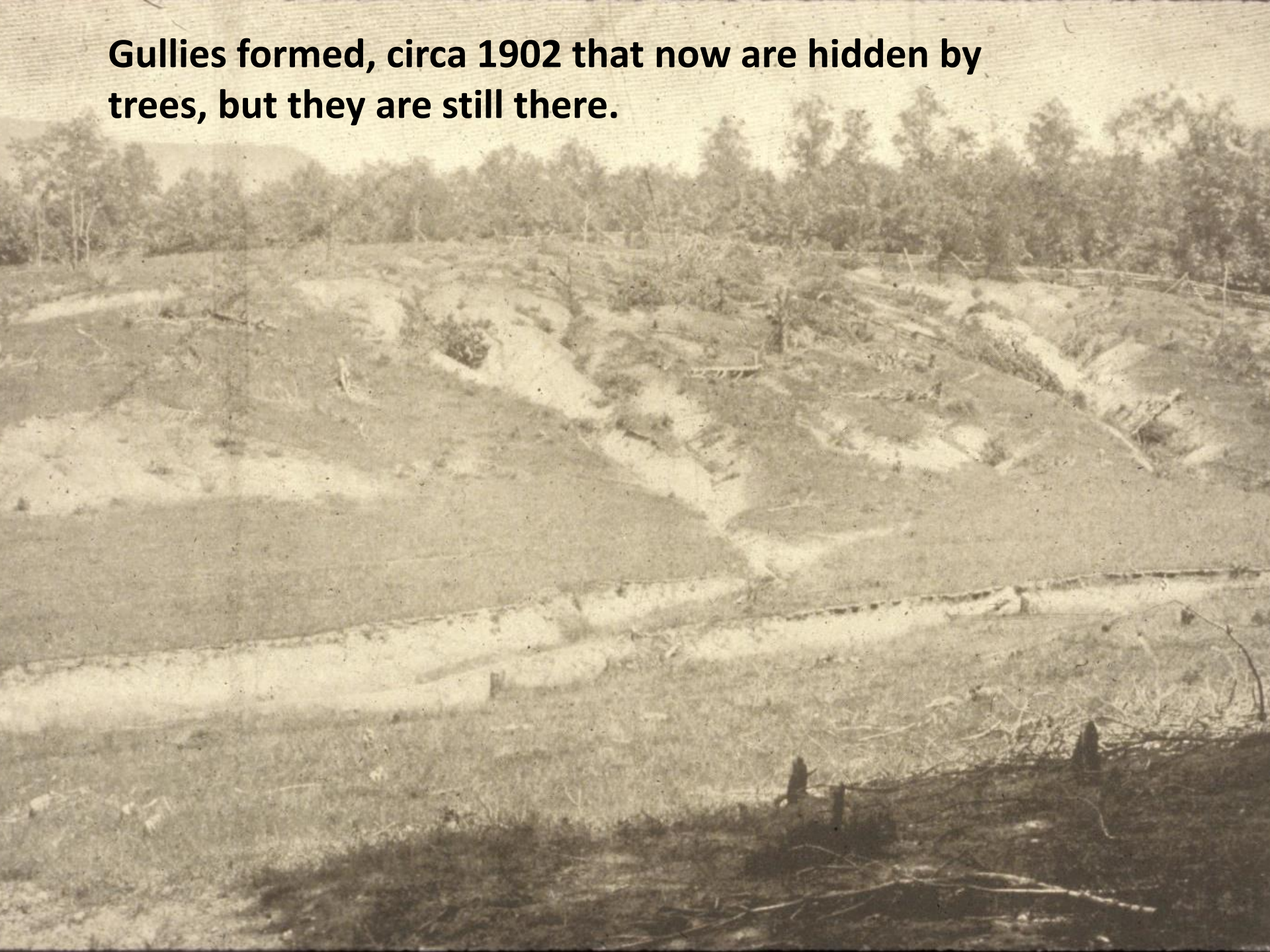
"The first settlers, therefore had nothing but to select the most promising spots, clear away timber, and loosen the soil, so that vegetables to be grown could strike their roots into it. As the fertility which they had first found was, in the course of a few years, exhausted, it became necessary, either to provide the means of renewing it, or find another tract and bring it under cultivation. As it was found that the latter could be done at the least expense of time and labor, it was perfectly natural that the exhausted land should be thrown out and fresh ground brought under tillage.

This process has been going on till most of the tracts whose situation and soil were most favorable to agriculture, have been converted into old fields and in our search after fresh ground to open we are driven to such inferior ridge-land as our ancestors would have passed by as not worth cultivating."

Professor Mitchell Speech in 1822



Evidence of abandon slash and burn field in the foothills of North Carolina, circa 1902.

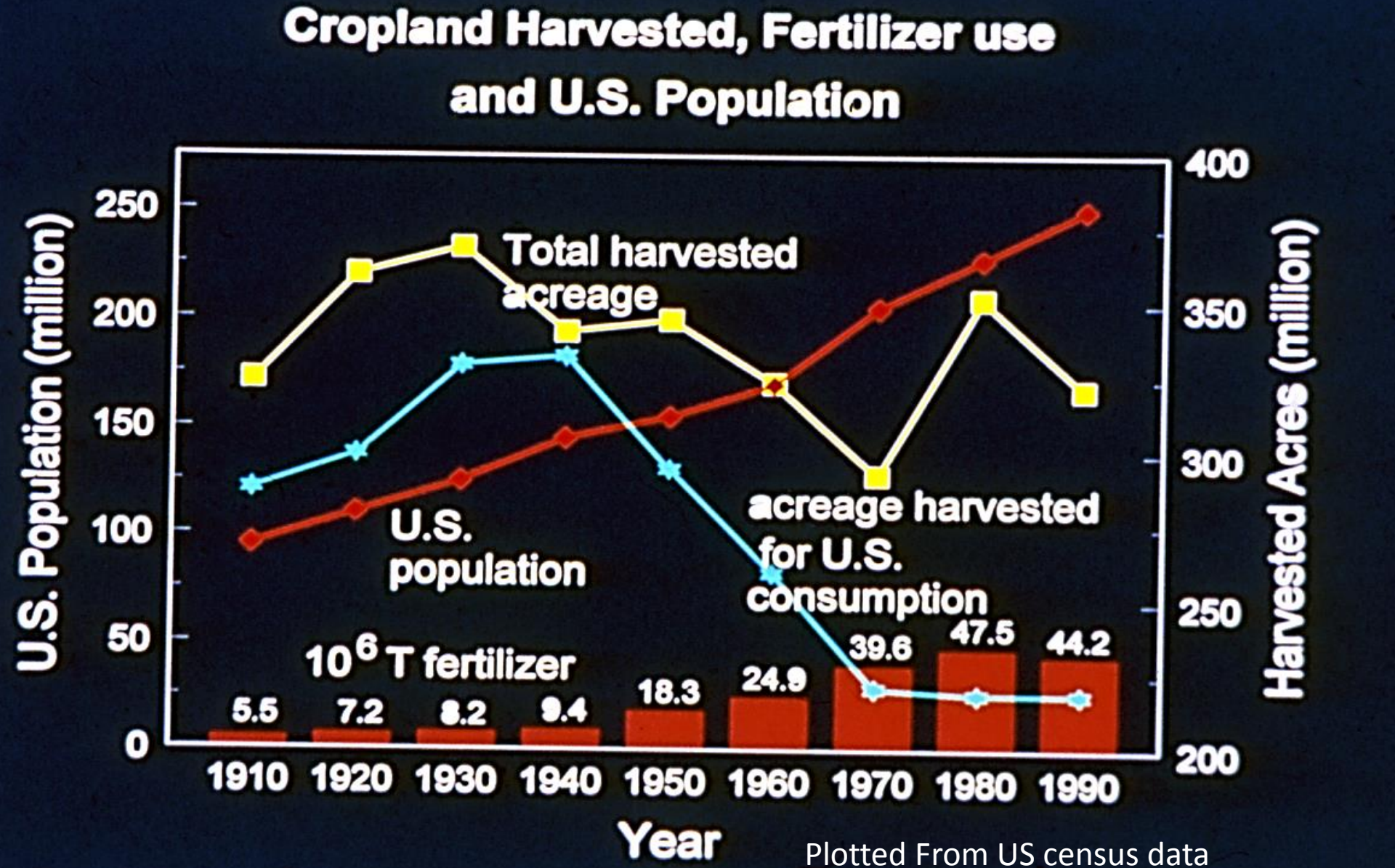

Gullies formed, circa 1902 that now are hidden by trees, but they are still there.

Historical Comparison of Average Farmer Fertilization Rates on Norfolk (Ultisols) and Tama (Mollisols) Soils in the US

(Original data from Soil Survey Reports and Unpublished Agricultural Extension Service records.)

	Element	Norfolk Soils (NC)		Tama Soils (IA)	
Year		1925	1983	1919	1979
Corn Yield (Bu Ac^{-1})		32	110	42	130
Fertilizer Rate (Lb Ac^{-1})	N	32-47	120-158	0	150-180
	P	3-5	18	0	30-48
	K	5-10	67	0	67-99

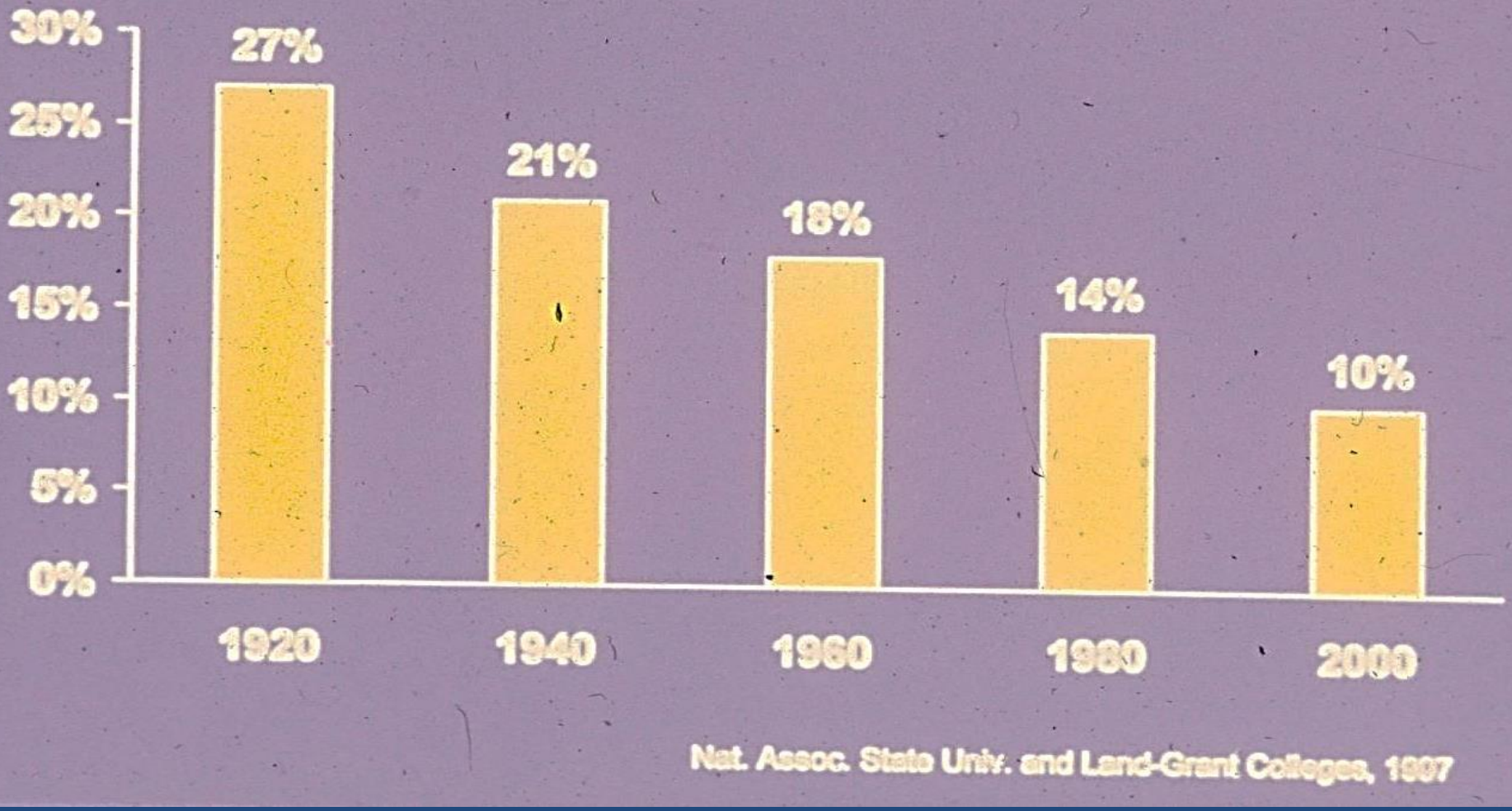
Mollisols are naturally more fertile than Ultisols but even the most fertile soils now require more fertilizer to support the higher yields provided by the high genetic potential of hybrids and genetically modified crops.



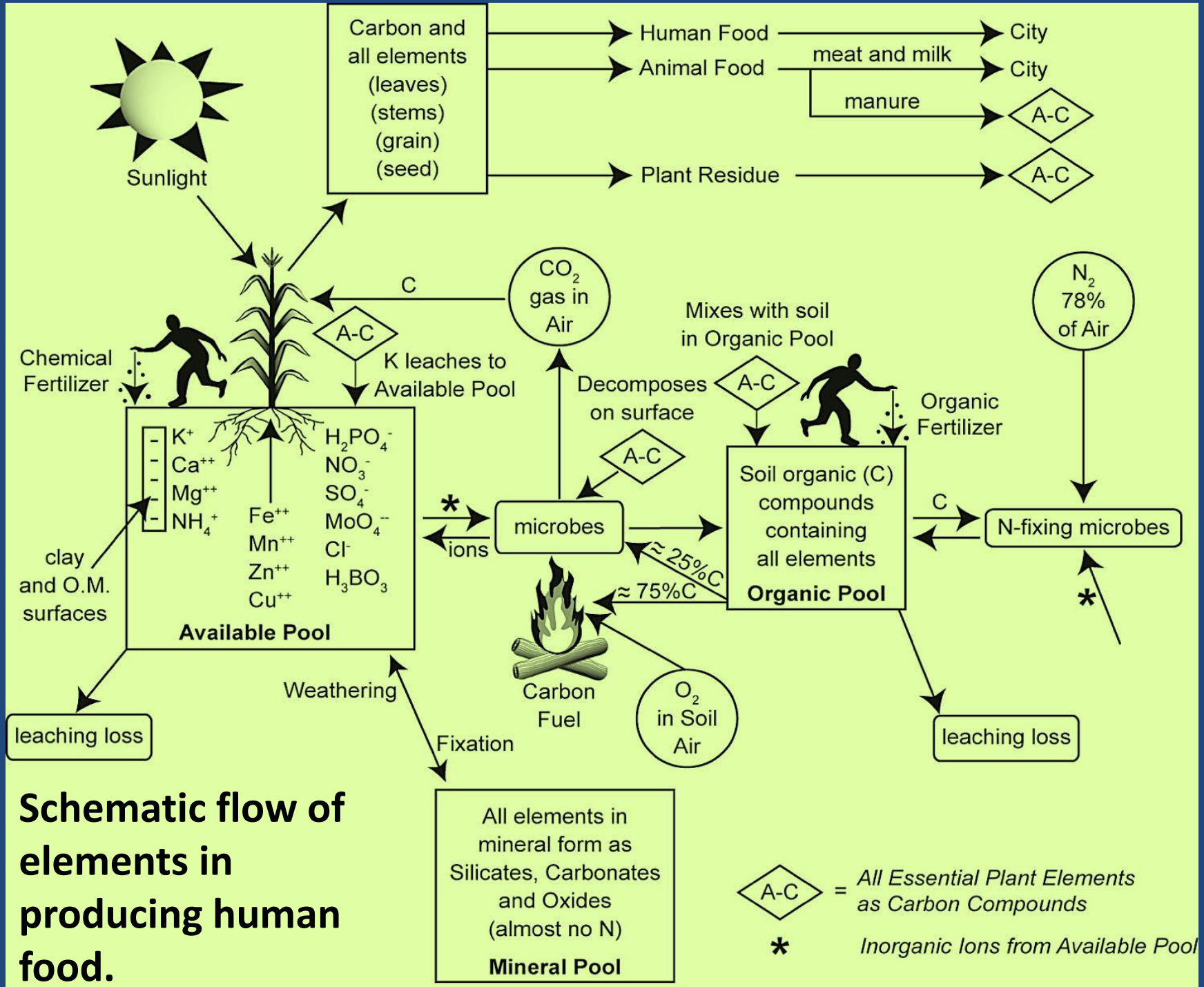
Plotted From US census data

US soils are the same but what they do growing human food has changed with fertilizer, mechanization and genetic improvements.

Percent of Income Spent on Food



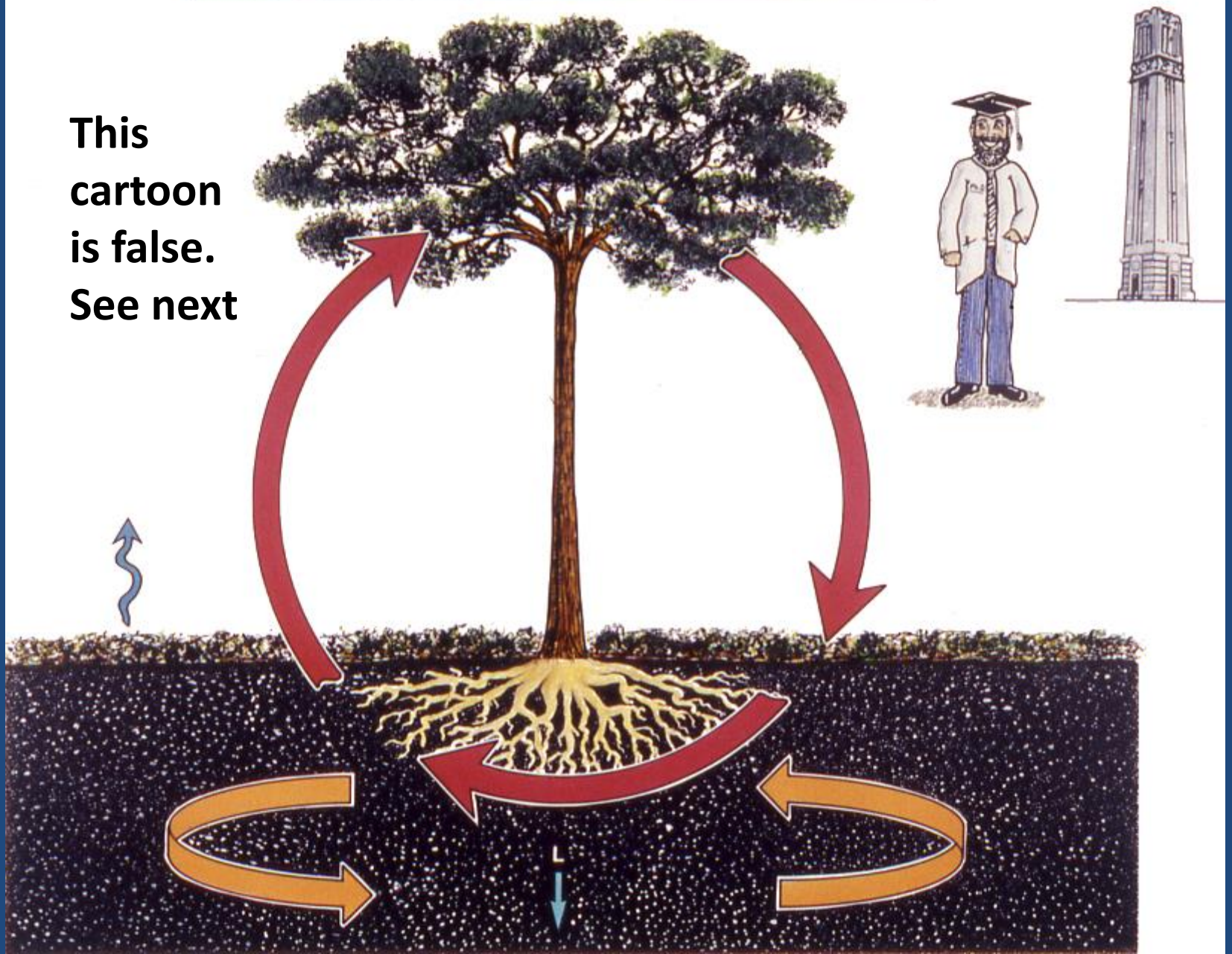
Increase production per acre has benefited everyone.



Schematic flow of elements in producing human food.

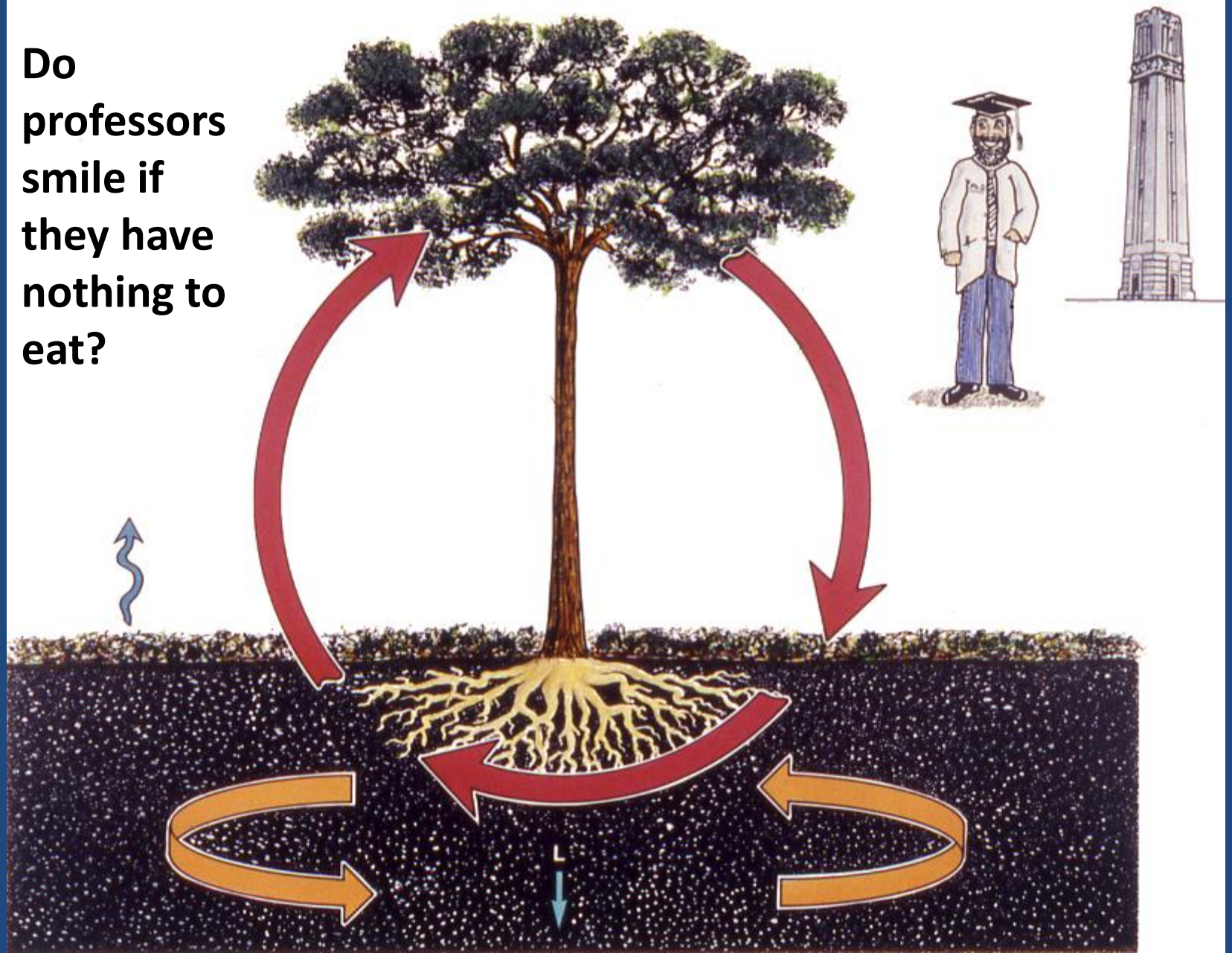
Natural System

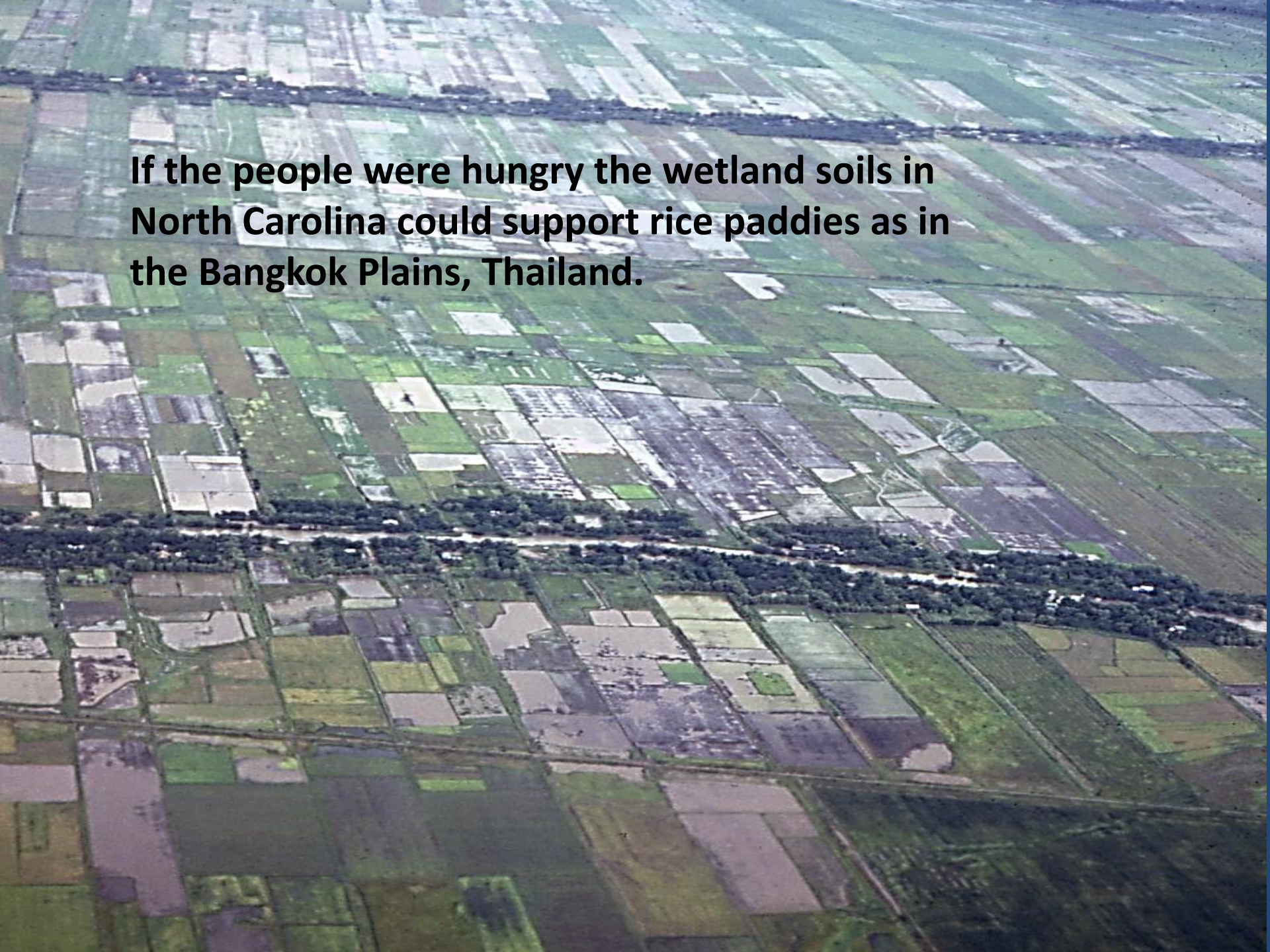
This cartoon is false. See next



Un Natural System

Do professors smile if they have nothing to eat?




If the people were hungry the wetland soils in North Carolina could support rice paddies as in the Bangkok Plains, Thailand.


If the people were hungry the North Carolina mountain soils could support subsistence slash and burn fields like these in Sri Lanka.

Only if people are well feed will old growth forests remain for future generations.

Well feed people provide space for other species to roam free like these elephants under the snows of Mt. Kilimanjaro.

A soil profile is inserted at the end of the rainbow over Victoria Fall, Because >

Soil is the pot of gold at the end of the rainbow that feeds the human species.

Thank You